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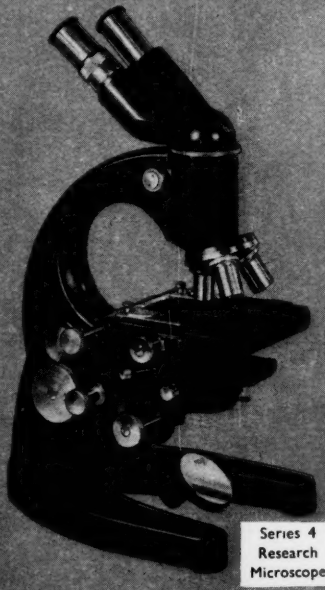

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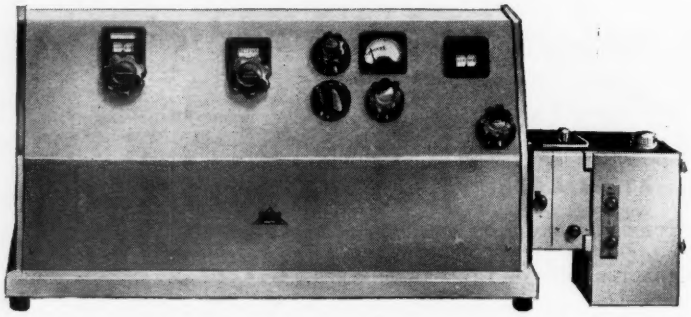

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NATURE CONSERVATION AND ECOLOGICAL RESEARCH

IN a country so thickly populated as Britain, the sequestration of land for purposes other than those of immediate economic or social advantage inevitably presents serious problems, of which the expenditure of public money on the project is but one. In response, however, to the recommendations of the reports of the Wild Life Conservation Committees which were published in 1947[1,2] there was established the Nature Conservancy, with the express intention that it should acquire and maintain land where it is regarded as necessary for the conservation of the flora and fauna, direct research on the ecology of the wild life of Britain and act as a clearing house for advice and information in relation to any problems which may arise in this ecological field, whether within its reserves or elsewhere in the country. It being recognized that such a service is primarily dependent upon long-term research, the wise decision was made that the Conservancy, like the Agricultural Research Council, the Department of Scientific and Industrial Research and similar bodies, should be responsible to Parliament, not through any departmental head, but direct through the Privy Council and its Lord President.

Despite having had barely ten years of functional existence, the Nature Conservancy has pursued a vigorous policy of implementing the major recommendations of the Wild Life Conservation Committees, which were embodied in the terms of reference under which the Conservancy was established. Thus, it now possesses or controls some 125,000 acres of land as National Nature Reserves, and may be regarded as approximately half-way towards attaining a final target comprising some 140 areas of land of the most diverse ecological interest. In addition, two field research stations, Merlewood at Grange-over-Sands and Furzebrook near Wareham, have been equipped; smaller provision of laboratories and equipment has been made at some of the reserves; while a system of regional officers exercises an all too slender integration of interests between the Conservancy and land-owners and land-users throughout the country.

The Select Committee on Estimates has recently[3] subjected the affairs of this youngest of our scientific services to scrutiny and has expressed its satisfaction with the potential value to the country of its work. To the scientific ear there is an oddly parochial ring to the qualification: "It is important that wisdom and common sense are brought to bear in selecting projects for research which will redound to the prestige and prosperity of the nation". But we may rest assured that so small an objective will be achieved within the framework of the Conservancy's policy of enlarging our knowledge of the ecology of the British Isles, and it is a matter for satisfaction to biologists that this framework has received approval. The Select Committee's sympathetic appreciation contains four major reservations. Of these, two relate to the administrative organization of the Conservancy and can be left for adjustment to the domestic wisdom of those immediately concerned. The other two, however, relate to scientific policy and call for some comment.

It is a matter of concern to the Select Committee that on one hand the Conservancy is committed to a policy of increasing substantially, and as rapidly as possible, its holding of nature reserves, while on the other the provisions for staffing and maintaining some of those already acquired are very thinly spread. The Committee accepts that it is vital to complete as early as possible the programme of dedication of National Nature Reserves, if only to secure that too much is not lost to the demands for development which are being actively pressed by many interests. But it foresees, with some alarm, that management of the new reserves, even in a manner comparable only with that of existing areas, must result in the presentation of bills for equipment, maintenance and staff which must swell the Conservancy's annual budget by considerable sums. Moreover, the visiting sub-committee which inspected Moor House Reserve in Westmorland was clearly appalled by the difficulties and hardships suffered by workers there, with no telephonic communication and only a badly surfaced seven miles of moorland track and a 'Land Rover' as their link with civilization. It may be commented in passing that such conditions, while clearly difficult for the administrator and the lay worker, may be regarded as almost normal by the field biologist, and indeed such remote isolation is eagerly sought by them for the freedom from interference and interruption by the public which they offer.

The solution to the problem offered by the report of the Select Committee is the recommendation that existing reserves be given prior claim on finance both for maintenance and for research, except where it appears that a newly acquired reserve may be liable to deteriorate in scientific value unless it is adequately staffed and managed. This same problem of provision of, in particular, scientific staff is evidently in mind in the subsequent suggestion, that greater efforts be made to induce the universities to play a larger part in the ecological investigations of the Conservancy. It is not, of course, within the terms of reference of the Select Committee to recommend expenditure beyond the estimates which are under consideration. It is, however, difficult to escape the conclusion that this may become necessary if the Conservancy is to

play its proper part. At present we spend annually something of the order of twopence a head of population on its work, and this figure will rise to nearly threepence by the time the programme of acquisition of reserves had been completed. This by any standard cannot be described as extravagant, and contrasted with expenditure on parallel projects in the United States and elsewhere it is conservative. Moreover, by virtue of our situation on the seaboard of Europe and, above all, of the extreme geological diversity to be found within so small a compass within the British Isles, it is probably true that ecological conditions present a far broader variety here than is to be found in close proximity almost anywhere else in the world. It follows that, to achieve its primary object of understanding the ecology of Britain, the Nature Conservancy must be able to prosecute at one and the same time active research in a number of different reserves. It is true that attainment of such an objective is far distant, and inevitably priorities must be determined. It is also true, however, that the pace and intensity of human interference with natural conditions have increased out of all measure during the past fifty years, and is still increasing. It is therefore most urgent that we should endeavour to obtain at least an inkling of the effects of our activities upon the world around us, and for this we need a yardstick in the form of some documentation of the conditions in those areas which have suffered least interference by man, and still remain to us. A substantial increase in the annual budget of the Nature Conservancy may well, therefore, prove a long-term economy in saving us from the ecological mistakes the cost of which in the past may be readily appreciated from a perusal of Mr. C. S. Elton's latest book[4].

A strengthening of the link between the Conservancy and the universities will undoubtedly be welcomed by both parties. There are, however, difficulties which must be faced. In most universities the disciplines cognate to ecological research tend to be departmentally isolated, and the workers themselves are for the most part unused to the discipline of team-work such as is demanded by most of the Conservancy's major projects. In addition, too, many senior workers are caged by administrative and teaching duties to such an extent that they are rarely free to undertake full ecological investigations, most of which demand freedom to attend to them in the field throughout the year. This handicap becomes particularly forceful where the region of study is, as are most of the National Nature Reserves, remote from the individual's laboratory. It follows that the conscientious university teacher must, if he is interested in ecology, do a great deal of his work by proxy, building up a school of young research workers under his inspiration and guidance. This immediately brings back the problem of finance. Now the Nature Conservancy at present spends about 10 per cent of its annual budget, namely, some £30,000, in subventions for ecological research by university and other workers outside its immediate orbit. This, in 1957, enabled the Conservancy to support sixteen senior university workers and some thirty post-graduate students; but owing to financial stringency it was impossible to consider making any new grants during the year despite requests in relation to a number of important projects. It seems, therefore, unrealistic to expect increased co-operation from universities, the resources of which are already over-strained, in the absence of any means of providing the financial support this demands.

It is necessary to join issue with the Select Committee over its recommendation 19 on the subject of revenue. This postulates that the Conservancy should make greater efforts to obtain revenue from its reserves and, by implication, should instruct its regional officers to give time and thought to devising means of deriving some income from the reserves in their charge. It cannot be too strongly emphasized that the functions of the Nature Conservancy are those of research, conservation and advice; its regional officers provide the main lines of liaison in relation to these services, while the reserves are its laboratories. These officers are few in numbers and each is already fully occupied with a large area in which to exercise a variety of delicately adjusted functions. None is by training as equipped to deal with the commercial transactions envisaged as is the land agent, and it would severely handicap them in the performance of their scientific duties were they called upon to look for revenue from their reserves.

On the larger issue, that the Conservancy should be expected to seek to derive profit from its lands; first, it must be realized that most of the land on which reserves are situated is very poor, this being one of the major reasons underlying its selection. But apart from this, it is not the function of research laboratories to make money out of side activities, and it would seriously handicap the progress of original investigations should such a duty be imposed upon them. This is not to suggest that where a market exists for the end-products of the normal research and maintenance activities carried on, this should not be exploited. Indeed, the officers of the Conservancy have produced evidence that a small revenue is derived from sales of timber and the like and from grazing. This must, however, be allowed to remain incidental to the scientific management if the reserves are to be efficiently maintained. It is frequently necessary to extinguish sporting rights and to modify the management of land in order that a natural—or more natural—balance may establish itself for the purposes of the scientific investigations, the results of which will provide ultimately a true profitable return in an increased knowledge of the causes which underlie natural processes and the results of our maltreatment of them.

[1] Conservation of Nature in England and Wales. (Cmd. 7122.) Pp. v+139. (H.M. Stationery Office, London, 1947.) 4s. net.

[2] National Parks and the Conservation of Nature in Scotland. (Cmd. 7235.) Pp. iv+72. (H.M. Stationery Office, London, 1947.) 2s. net.

[3] Seventh Report from the Select Committee on Estimates together with the Minutes of the Further Evidence taken before Sub-Committee C and an Appendix. Session 1957–58. Nature Conservancy. Pp. ix+79. (H.M. Stationery Office, London, 1958.) 5s. net.

[4] Elton, C. S., "The Ecology of Invasions by Animals and Plants" (Methuen and Co., Ltd., London, 1958).

CHARACTERISTICS OF THE BARTONELLAS

Morphologische, Biologische und Serologische Eigenschaften der Bartonellen

Von Dr. Reinhard Wigand. Pp. viii+71. (Stuttgart: Georg Thieme Verlag, 1958.) 7.80 D.M.

THIS book is not a monograph on bartonellas, which, by the way, would be most welcome. It gives a detailed record of the author's own work on the subjects mentioned in the title.

Electron microscopical studies have mainly confirmed early observations. They have, however, made possible precise measurements of the various members of the group. (The reader should note a printing error: the flagella of *Bartonella bacilliformis* are not 20μ thick as stated on p. 23.) The cytochemical studies have shown that both *Haemobartonella muris* and *Eperythrozoon coccoides* contain ribonucleic and deoxyribonucleic acids. The conclusion concerning the structure of their outer layer is somewhat obscured by the fact that Wigand uses the term membrane loosely, and not in the modern sense, as opposed to bacterial wall. The study of the action of antibiotics is reported in detail and the tables giving the comparative sensitivity of various bartonellas to antibiotics are certainly useful. So far as infection with *H. muris* is concerned, the statement that a complete picture of infection is observed only in splenectomized mice is not valid. The work of Gledhill and Andrewes concerning the co-operative action of *Eperythrozoon* and of the virus of hepatitis could perhaps have been quoted in the discussion of the pathogenic activity of *Eperythrozoon*.

The demonstration by Wigand of a serological relationship between *H. muris* and *Eperythrozoon* is important. It was predictable since a typical *Eperythrozoon* phase has been recognized in *Haemobartonella canis* (which should have been mentioned in the book). This poses the problem of the 'round' form of *Bartonella bacilliformis* observed by Noguchi and which is interpreted by Wigand as the result of a degeneration. The bodies observed by Noguchi, however, are indistinguishable from typical *Eperythrozoon* and are not to be confused with the coccoid forms of involution so easily observed in bartonellas, or in any other bacteria. It is clear that if an *Eperythrozoon* phase exists in the life-cycle of the human *Bartonella*, the problem of its affinities would have to be reconsidered.

Wigand has not been able to detect serological relationships between *Eperythrozoon* of the mouse and *Anaplasma* of the bovines. It seems perfectly justifiable, however, to conclude, with Wigand, as was already done in 1931 by Lwoff and Vaucel, that the two organisms are related.

According to Wigand, *Bartonella* is a bacterium. *Haemobartonella*, however, is supposed to lack any of the typical features of bacteria. It is neither a virus nor a protozoon. For Wigand, they resemble the pleuropneumonia group of organisms. But these, being bacteria, certainly possess some features of the Schizomycetes group. If *Haemobartonella* and *Eperythrozoon* are pleuropneumonial-like organisms they should also possess bacterial characteristics. Otherwise, they would belong nowhere. Finally, the reader is puzzled by Wigand's statement that *Hæmobartonella* and *Eperythrozoon* are devoid of a membrane, of an internal structure and of cellular organization (p. 26). How these strange creatures, which, by the way, are extracellular parasites, manage to grow, to multiply true to type and to survive, is a mystery. The very existence of *Haemobartonella* and *Eperythrozoon* would, in my opinion, make it probable that, like all other organisms, they do have a cellular organization.

Despite the absence of index, the specialists on *Bartonella* and *Haemobartonella* will find in this book a number of useful technical, electron-microscopical, chemotherapeutical and serological data.

A. LWOFF

COLORIMETRY IN BIOCHEMISTRY

Colorimetric Analysis

By Noel L. Allport and Dr. J. W. Keyser. Vol. 1: Determinations of Clinical and Biochemical Significance. Second edition. Pp. xi+424. (London: Chapman and Hall, Ltd., 1957.) 50s. net.

COLORIMETRIC analyses, using photoelectric apparatus to measure the intensity of transmitted light, are nearly always superior to gravimetric or titrimetric methods in speed of assay and in the avoidance of the exercise of personal judgment in making the final readings. Moreover, the cleaning and maintenance of apparatus are usually simpler in the case of colorimetric methods. It is not surprising, therefore, that in clinical biochemical work colorimetric methods are often the methods of choice; their slight inferiority in accuracy, in some cases, being offset by their suitability for the performance of large numbers of routine assays.

In the volume under review Mr. N. L. Allport and Dr. J. W. Keyser have given us a collection of about one hundred colorimetric techniques, covering a much wider range than that usually needed in clinical work. This volume is an extension and revision of section three of the first edition, published in 1945, which dealt with analyses of clinical and biochemical significance. The number of analyses described has been increased about threefold. Among the additions specially likely to interest the clinical chemist, assays of adrenocortical steroids, bromsulphthalein, congo red, dextran, dinitro-orthocresol, Evans blue, inulin, protein-bound iodine, acid optimum phosphatase activity and urobilinogen should be noted.

As in the first edition, description and discussion of colour-measuring apparatus have not been included. The critical selection of material, valuable discussion of each method, and clarity of presentation which were striking features of the first edition have been fully retained.

The wide range of analyses covered adds greatly to the general interest of the book. The clinical chemist should find here many suggestions for additions to his established routine and for techniques which show improvements on the older methods.

Colorimetric methods cannot always be the methods of choice. This is recognized and indicated where necessary, as, for example, in the description of the assay of calcium in serum, where the well-established and straightforward titration of the precipitated calcium oxalate receives due recognition.

In the section dealing with the assay of carbon monoxide in blood, a good feature is the inclusion of the old, but simple and reliable, tannic acid technique. However, the titrimetric technique

using the Conway micro-diffusion unit, and based upon the liberation of hydrochloric acid from palladium chloride by carbon monoxide, would probably be the method of choice in most clinical laboratories.

One wishes that the important question of the assay of adrenaline and noradrenaline in urine could have been discussed in the section on adrenaline assay. In recent years clinicians have shown a keen and very understandable interest in this assay, because it is a valuable diagnostic aid for investigating patients suspected of harbouring a phaeochromocytoma. While assay by the cat blood pressure technique is probably the method of choice, many laboratories have no facilities for this procedure. Colorimetric methods have been described, but only techniques involving measurement of fluorescence in ultra-violet light seem at present to be adequate.

In the section dealing with the assay of uric acid in blood no mention is made of the simple procedure of Benedict and Behre for removing the interfering substance thioneine from blood filtrates. Doubtless the authors consider this refinement unnecessary for both the methods they quote, but it should be borne in mind by all concerned with this assay.

An appendix to this book gives, with references, a list of thirty-two further methods, not included in the text. A short description of the principle underlying each of these methods is included. Finally, full indexes of authors and subjects conclude a practical and interesting volume which should certainly find a place in the laboratories of all who use colorimetric methods in clinical or biochemical work.

N. R. Lawrie

AFRICAN APHIDS

A Study of the Aphididae (Homoptera) of East Africa

By V. F. Eastop. (Colonial Research Publications.) Pp. vi+126. (London: H.M. Stationery Office, 1958.) 27*s*. 6*d*. net.

It is surprising that so little attention has been paid to surveys of the aphid fauna in the tropical and subtropical countries of the world in view of the economic importance of this class of insect. This is particularly true of Africa south of the Sahara, where the fauna has never been systematically studied and where, in consequence, many of the names that have been in common use in East Africa have now been found to be wrong. Yet it is of vital importance to the economic entomologist that he should know accurately the identity of the species with which he has to deal if he is to be able to benefit from the experience of others and from what has been recorded about it. Furthermore, in recent years, the Aphididae, as proved vectors of plant diseases, have assumed an even greater economic importance.

The objects of the present work, according to the author, are to provide a means of identifying those aphids known to occur in East Africa, to make possible the identification of those species occurring in adjacent territories that are not known from East Africa at present, and finally to bring together under each species the biological data available.

The foregoing objects have been admirably achieved. The number of known species from the region has been increased from 30 to 80, any one of which can be run down by following the keys which take one through each category of the classification down to species. Mistaken identities of some species are rectified and other species are synonymized. A new species and a new subspecies are described and recognition characters are given in the case of most species. The figures are adequate but their arrangement and that of the legends might have been improved. A list of host plants arranged alphabetically in families and of genera within families will be most helpful in providing an indication of the possible identity of an aphid species and will form the basis of a much more extended list as more knowledge is accumulated. The book is indexed and a comprehensive list of references is supplied.

This is the type of taxonomic work that is so valuable, and becoming increasingly more so, to the economic entomologist. It is the first survey of its kind made in East Africa south of the Sahara, and it should enable entomologists and agricultural officers to recognize their species accurately.

The Colonial Office is to be congratulated on promoting this study, and it is to be hoped that it will be followed by similar surveys in other areas of Africa and elsewhere. If they are all as well and carefully executed as in the present instance they will mark an important advance.

W. J. Hall

PSYCHIATRY IN WARTIME

Psychiatry in the British Army in the Second World War

By Robert H. Ahrenfeldt. Pp. xv+312. (London: Routledge and Kegan Paul, Ltd., 1958.) 35*s*. net.

Dr. Ahrenfeldt fights once again the battles fought during the Second World War by British Army psychiatrists, "unwelcomed and regarded with suspicion, if not despised, . . . to overcome prejudices, administrative resistance and executive inertia, while simultaneously caring for their patients . . ." (p. 251). The brave partisan attitudes so frankly displayed in this passage pervade his book. They are not compatible with a discerning appraisal of the scientific, technical or administrative problems. Yet account should be taken of them by everyone who studies the history of Army psychiatry, or, for that matter, the development of civilian psychiatry in the years immediately following the War, because they appear to have been shared in some degree by several of his colleagues. Whether or not Dr. Ahrenfeldt wins the reader's sympathy, his book serves a useful purpose as a concise and accurate chronicle of the changes in official policies during the War years.

Let no one diminish the achievements of Army psychiatrists. A great deal was demanded of them. Equipped with the knowledge and skills acquired during their medical training and their specialist experience in hospitals and private consulting rooms, they were required to tackle not only the problems of organizing the treatment and disposal of psychiatric casualties, but also the multifarious problems of personnel and officer selection, training, discipline and morale and the management in Army units of the dull, unstable and delinquent. They had to be experts in matters lying outside their previous experience because there were no other experts. Many of the problems had been recognized in the First World War, and were noted in the report of the Southborough Committee in 1922, but the Army entered the Second

World War without any organization or trained staff to meet them. The Royal Navy and the Royal Air Force were perhaps more successful than was the Army in utilizing the services of civilians trained in the methods of social and applied psychology, and the psychiatrists in these Services dispersed their efforts less widely.

Many of the criticisms to which Dr. Ahrenfeldt makes reply appear to have arisen when the expertness of psychiatrists was called in question. For example, their participation in the selection of officers at War Office Selection Boards was controversial. A special position was claimed for the psychiatrist "as the only member of the Board with adequate scientific training and experience in the assessment of personality" (p. 66). Yet it could reasonably be doubted whether he was therewith fitted for the position claimed for him. The problems were new ones, and the immodest insistence by some psychiatrists of the superiority of their theories and techniques, in this and other matters, did damage to their reputation. However, in assessing the rights and wrongs of their claims, it should be remembered that the problems were important and urgent.

D. Russell Davis

PHONETICS

Manual of Phonetics

Edited by L. Kaiser. Pp. xv+460. (Amsterdam: North-Holland Publishing Company, 1957.) 38 guilders.

THIS book is divided into six parts, dealing respectively with the history of phonetics, the basal sciences of phonetics, phonetic research, phonetics in its relation to linguistics, phonetics in its relation to other sciences, and phonetics and the origin of speech. The twenty-eight chapters which make up these six parts have been contributed by thirty different authors (there are several collaborations), coming from fourteen different countries; they all write in English, sometimes in an English that is not very easy to follow. Curiously enough there is no contributor from Britain. The editor's introduction explains that the book is not addressed to a specialist audience, but is intended to provide a general introduction to the subject for such people as engineers, linguists, surgeons, psychologists, teachers, artists, and so on; and it is claimed that an all but complete survey of the field is provided. This, indeed, is what one would expect from a book entitled a 'manual'.

However, it is a disappointing compilation. It is certainly not a 'manual', in any sense, but is rather a collection of essays which have little unifying force behind them, and which are, moreover, of very varying worth. It does not provide anything like a complete survey of phonetics. The fundamentals of the subject are almost entirely missing: there is no detailed, systematic treatment anywhere of the basic categories of phonetic description, though such a treatment is needed for understanding many of the contributions; and there is no account of phonetic notation, apart from a few brief (and inaccurate) notes, at the beginning of the book, on the symbols used by the contributors (some of whom deviate unexpectedly from accepted practice). The languages taken into consideration fall very far short of being representative of the general range of human phonetic performance.

It is disconcerting that some of the contributors do not appear to be phoneticians at all; one wonders what the collaborators who are phoneticians think of certain of the statements with which their contributions find themselves in company (such as one to the effect that "the average baby, under two months of age, is endowed with 7½ phonemes"). Several important techniques of phonetic research, including palatography and kymography, are referred to but nowhere explained. No mention is made of the uses of recording in phonetic investigation, and there is no discussion of methods of teaching pronunciation.

It is almost inevitable, in a work planned as this one appears to have been, that there should be no general body of theory common to all the contributors; it is scarcely surprising, therefore, that they contradict each other at times. More effort could have been made, however, to unify terminology: we find the same term used in two, and sometimes three, different senses by different writers (vocalization, accent, implosion, for example). What is more serious is that some terms are not explained anywhere in the book (for example, mixed vowel, lenis, fortis). A glossary of technical terms should have been provided. Even a carefully prepared index would have been a help; the present one is quite inadequate.

There are outstanding contributions by Peterson, Martinet, and Jakobson and Halle; but it is nevertheless not possible to recommend the book (quite apart from its price) to the layman who wants a manual of phonetics.

D. Abercrombie

SIR CHARLES SHERRINGTON

Sherrington

Physiologist, Philosopher and Poet. By the Rt. Hon. Lord Cohen of Birkenhead. (The Sherrington Lectures, 4.) Pp. xiv+108+3 plates. (Liverpool: Liverpool University Press, 1958.) 17*s*. 6*d*.

THIS volume is the fourth of the series of Sherrington Lectures instituted by the University of Liverpool in recognition of the distinguished contributions of the late Sir Charles Scott Sherrington to physiology and medicine, and of his association with the University as its George Holt professor of physiology during 1895–1913.

Lord Cohen has been the University's professor of medicine for a generation, and has chosen for his theme a much more personal subject than have the previous lecturers. He has also given reproductions of the Augustus John painting which hangs in the University Club of Liverpool, and of that by R. G. Eves which is in the Royal Society of London, as also of the photograph by Allan Chappelow which was chosen by Sherrington as the frontispiece to the second edition of "Man on his Nature", which was published on Sir Charles's ninety-fourth birthday. Apart from these three plates and a number of text figures, the book contains in its 108 pages a brief introduction, Lecture 1 which is biographical, Lecture 2 which deals with Sherrington as physiologist, and Lecture 3 which is of him as philosopher and poet. To these are added a bibliography, based on writings compiled for Denny-Brown's edition of "Selected Writings" and on John Fulton's obituary notice in the *Journal of Neurophysiology*.

Not so long ago it was a considerable labour and effort to piece together Sherrington's biography, but thanks to Prof. E. G. T. Liddell ("Obituary Notices of Fellows of the Royal Society", **8**, 241; 1952), Lord Adrian (*Proc. Roy. Soc. Med.*, **50**, 991; 1957), and others the effort has long since become less exacting, and opportunities for originality in Lord Cohen's Lecture 1 correspondingly less. One should, however, add the Beaumont Lecture given at Yale University on November 15, 1957, by "Sherrie's" son, Mr. C. E. R. Sherrington, for it is a noteworthy complement to other sources and is not too widely known.

Of his Lecture 2 Lord Cohen modestly wrote, "I have been able to touch only briefly and superficially on Sherrington's contributions to physiology. The work of a genius, who for half a century laboured with undiminished zest to unravel some of Nature's secrets, cannot be compressed, even in its essentials, into one lecture. It may well be that others would have chosen different examples from his work and a different emphasis to convey their assessment of his contribution to neurophysiology". Lord Cohen also refers to Sherrington's influence on the development of clinical neurology, where not only did he add, "as no-one had previously done, to the facts but above all he provided the concepts which made them hang together".

Lecture 3 is the most difficult to review, for it passes from physiology to the age-old problem of life and mind, posing difficulties at which Sir Charles did not baulk but which he recognized rather than solved. Then it completes the writer's would-be scope by referring to Sherrington's poetry and poetic thought, which make up a very interesting part of the full story, but need a poetic atmosphere for their proper discussion.

This review cannot give that, but perhaps enough has been said to reveal the scope of the lectures, and to whet the would-be reader's appetite for more. One cannot be too much in thought with Sherrington, or be too thankful that so wonderful a person lived in our time. We are in debt to Lord Cohen for his delightful tribute to so outstanding a member of the Liverpool faculty of an earlier day.

K. J. Franklin

MISSILE ENGINEERING DESIGN

Missile Engineering Handbook

By C. W. Besserer. (Principles of Guided Missile Design, Vol. 4.) Pp. xi+600. (Princeton, N.J.: D. Van Nostrand Company, Inc.; London: D. Van Nostrand Company, Ltd., 1958.) 109*s*.

Guided Missiles

Operations, Design and Theory. (Sponsored by the Department of the Air Force.) Pp. vi+575. (New York: McGraw-Hill Book Company, Inc.; London: McGraw-Hill Publishing Company, Ltd., 1958.) 62*s*.

THE ever-increasing development of guided weapons for military purposes, research rockets for upper atmosphere measurements, and earth satellites and space probes implies a huge host of scientists, technicians and engineers working in the many disciplines of science and technology involved in these new devices. Despite the growing need for authoritative text-books on the associated wide range of applied science, it has, until recently, been difficult to find more than semi-popular expositions, liberally strewn with illustrations of war-time German missiles and American missiles at the instant of launch. The American series of admirably produced volumes on "Principles of Guided Missile Design", edited by a retired U.S. Navy captain for many years closely associated with missile development, and published by Van Nostrand, has gone far to rectify the situation.

This series began in 1955 and the fourth volume—"Missile Engineering Handbook"—is intended as a compendium of design data for use by engineers and technicians who may be assumed to have acquired a good knowledge of basic principles from the earlier volumes. It contains 400 pages of closely packed tables, graphs, nomograms and charts providing a remarkable accumulation of engineering data in the various subjects which make up the complex applied science of missile design. One may browse through specific gravity tables with such curious items as porphyry, hemlock or pine-yellow long-leaf, and speculate on their usefulness in the mundane business of fabricating anti-aircraft rockets, or pause to check the cumulative probability of meteor hits on journeys through space. In the intervals, however, can be found exhaustive tables of properties of materials, rocket propellant performance, the Earth's principal characteristics and gravitational field out to great heights and many other topics, together with most of the basic formulæ useful for design calculations. Much information is given of great value for preliminary design studies, divided into chapters on properties of the atmosphere, materials, aerodynamics, propulsion, avionics and space flight. The data on materials and structural design are particularly extensive. However, the sections on specifications for environmental tests and ground equipment and what seemed to be reminder lists for the process of detail design, all based on American practice, are of limited interest. The chapters on aerodynamics and avionics are rather brief. At the end is a 160-page glossary of terms commonly used in missile engineering, which should prove most valuable to newcomers in the subject. The layout and printing are extremely clear. There are, however, quite a number of misprints and some errors in basic constants, for example, the powers of π on p. 23 are completely inaccurate. These errors raise some doubts regarding the accuracy of the multitude of quantitative facts throughout the book, which only detailed and intensive study could check.

By contrast the second book, "Guided Missiles—Operations Design and Theory" deals almost entirely with elementary principles. It is based on a military training manual written some three years ago at the U.S. Air Force Missile School in Colorado and is obviously intended for general instruction of military personnel. Although at times unsound on basic principles, for example, force, momentum and weight are sadly confused in stating Newton's laws, the book gives a very understandable account of the main design principles and features of typical missile guidance and control components. The sections on systems are less successful, and there are noticeable gaps in the treatment of servo-mechanisms and closed-loop systems. The text is profusely illustrated throughout by exceptionally clear line and half-tone diagrams. The subject-matter should be easily grasped by a reader with mathematics and science to Intermediate B.Sc. standard and, despite a tendency towards diffuseness and occasional inaccuracy, forms a good introduction to all aspects of missile development.

Basic Automatic Control Theory

By Prof. Gordon J. Murphy. (The Van Nostrand Series in Electronics and Communications.) Pp. xi+557. (Princeton, N.J.: D. Van Nostrand Company, Inc.; London: D. Van Nostrand Company, Ltd., 1957.) 9 dollars; 67*s*. 6*d*.

THIS book gives a detailed treatment for most of the basic theory pertinent to the analysis of linear feed-back control systems. The author deals first with Routh's criterion for stability, and with calculation of ultimate-state response. Techniques used in frequency response and time-response calculations are described. These include the G-plane (Nyquist) polar plot, the use of Bode gain-frequency diagrams, the root locus method for obtaining closed loop poles of the characteristic equation of a system from its open-loop poles, and the construction of the system time response from the closed-loop poles. Floyd's method for constructing impulse response from frequency response is also shown.

The introductory chapters, illustrated by a large number of very clear schematic and block diagrams, present various examples of control system components, and introduce the concept of transfer functions for each component part of a system. Block diagrams are built up for typical systems, and these are reduced to simple signal-flow diagrams. Laplace transform theory is also included among the introductory chapters, and the final chapter in the book gives a brief account of analogue computors and their use in simulation of feedback control systems. Certain parts of linear theory have been omitted, including the behaviour of linear systems with random input signals, and phase-plane analysis, but such omissions do not detract from the value of the book. Numerous worked examples are used throughout to illustrate the theory presented, and these examples are invaluable in providing a sound practical understanding of the subject. The book should prove useful to final-year and postgraduate students as well as to servo-design engineers, especially in respect to the excellent examples and unworked problems.

M. J. SOMERVILLE

Science in Schools

Proceedings of a Conference under the auspices of the British Association for the Advancement of Science, held on April 17th and 18th, 1958, at the Royal Geographical Society, London, S.W.7. Edited with Postscript by W. H. Perkins. Pp. viii+150. (London: Butterworths Scientific Publications, 1958.) 15*s*.

DURING April 17–18, 1958, the British Association for the Advancement of Science held a conference to focus attention on the condition of science teaching in schools. The subjects discussed included the national need, science as a component of general education, scientific education for girls, the present position of science teaching, the supply of science teachers and the role of the university and teachers' training colleges in providing them, accommodation and equipment and the part played by local education authorities in their provision. Among the speakers were Lord Heyworth, Sir Solly Zuckerman, Sir Eric James, Miss E. M. Huxstep, Dr. A. W. Barton, Dr. J. W. F. Hall, Dr. B. E. Lawrence and Lord Tedder. All the speeches and discussions have now been summarized in this book, which contains an introduction by Sir Alexander Fleck and a postscript by W. H. Perkins. The British Association and publishers are to be commended for presenting the proceedings of a nationally important conference in such attractive and readable form so quickly after the conference that the views presented are still fresh, lively and urgent.

Methods of Analytical Histology and Histo-Chemistry

By Edward Gurr. Pp. xv+327. (London: Leonard Hill (Books), Ltd., 1958.) 70*s*. net.

THIS is essentially a practical book designed for use at the laboratory bench, and, with this end in view, the techniques described have been set out very fully. The volume includes all the standard histochemical techniques, and often gives details of the several variants of any particular method. The difficult subject of protein histochemistry has been well covered; the very adequate instructions for the synthesis of some of the reagents used in, for example, the localization of sulphydryl groups by Barnett and Seligman's method are a welcome feature.

For the benefit of workers who do not have ready access to libraries, certain sections of the book are introduced by a theoretical passage which includes sufficient biochemical detail for a proper understanding of the different tests. The details of each reaction are followed by a selection of notes which point out possible sources of error, and these, together with a useful appendix containing such information as a list of buffer tables, of solubilities of various reagents and the formulæ of many dyes and staining solutions, add greatly to the value of the book, which may be readily commended to all who use histochemical methods.

S. BRADBURY

Curious Naturalists

By Dr. Niko Tinbergen. Pp. 280+54 photographs. (London: Country Life Limited, 1958.) 35*s*. net.

IN his introduction to this book, Niko Tinbergen describes it as the work of a small number of naturalists who, over a period of some twenty-five years, joined him in studying the behaviour of animals in their natural environment. He would be much too modest to say that most of the work described was initiated by him and continually inspired by his never-flagging enthusiasm. His friends throughout the world will greet his book with delight; many young naturalists will discover that the field of original investigation is still largely uncharted and awaits only the lively mind allied to a curiosity which is never stilled.

The book is cleverly written. In the opening chapter Tinbergen shows how, in the lovely country of Hulshorst in Holland, his first observations began in a somewhat diverting encounter with the digger wasp, *Philanthus*. From there the story is switched to East Greenland to the study of snow-buntings and phalaropes. Further investigation of *Philanthus* is followed by the study of the fast-flying falcon, the hobby. So the book continues with more studies of insects, birds and flowers, all serving to illumine contemporary knowledge of morphology, genetics and the mechanics of evolution.

The book is written in a narrative form which commands attention and is illustrated by superb photographs and quaint line-drawings which are always relevant to the text. "Curious Naturalists" should be much read.

THE GEOLOGICAL TIME-SCALE

By Dr. K. I. MAYNE
Clarendon Laboratory, Oxford

AND

Dr. R. St. J. LAMBERT and D. YORK
Department of Geology and Mineralogy, Oxford

THE sequence of geological events in many parts of the world since the pre-Cambrian has been well established by palæontological studies. The relative duration of each of the various periods into which it is customary to divide post-Cambrian time has also been estimated from a comparison of the maximum thickness of sediments laid down during each period. In order to use this relative scale as a time-scale, some geological events which are unambiguously placed in it, preferably within narrow limits, must be dated in an 'absolute' fashion. It is of course essential to make sure that one is dating the supposed event, and not some subsequent one. In this manner, Holmes[1] has proposed an absolute geological time-scale, his scale *B*, which places the Upper Cambrian at approximately 450 million years ago. Recently, we have undertaken an investigation of the ages of British igneous rocks by the argon – potassium method; and we have found discrepancies between the well-established stratigraphic assignment of our samples and the Holmes *B* time-scale. It appears that this scale is too short, and that the age of 450 m.y. given to the Upper Cambrian should be closer to 650 m.y. That the Holmes time-scale is too short has already been suggested by Ahrens[2] and by Faul[3], among others.

The 'absolute' age values on the Holmes scale are based upon seven uranium – lead ages determined by Nier[4]. Some of the specimens proved to have discordant age values, and those with ages which were concordant were of somewhat doubtful stratigraphic assignment. The discordancy had previously been thought to be the result of leakage of radon. For example, in the case of the Swedish Kolm, stratigraphically well defined in the Upper Cambrian, Nier's isotopic data for lead and uranium give age values for the ratio lead-207 to lead-206 of 800 m.y., for lead-207 to uranium-235 of 440 m.y. and lead-206 to uranium-238 of 377 m.y. Assuming loss of radon to be the primary cause of this discordance, Wickman[5] concluded that the absolute age of the Kolm is 440 m.y. It is thought that loss of radon is not significant except in the case of very young minerals[6]. Ahrens has suggested that the pattern of discordant ages found is due to loss of lead; and on this basis (with Nier's data) he has remarked that "slightly greater than 800 m.y. must be considered as a possible magnitude of the Upper Cambrian". More recently, Cobb and Kulp[7] have dated the Kolm, and although they find discordant lead-207/lead-206 ages as high as 720 m.y., they believe the true age to be no greater than 550 m.y. We are grateful to Prof. J. L. Kulp for informing us during the preparation of this communication that he now believes that his samples, and those of Nier's, may have been thermally altered by a basic sill occurring 100 m. above the Kolm. It would thus appear that so far the Swedish Kolm is open to criticism as a 'calibration point', for although its stratigraphy is well established, its age is still in doubt. On the other hand, the samarskite sample cited by Holmes, which is concordant in its age values, has an uncertain stratigraphic assignment, as indicated in Fig. 1. None of the samples used by Holmes is free of criticism on one or other of these grounds. Lead age data in many cases are not amenable to an unambiguous interpretation in order to give the true age. The argon – potassium method of dating may be able to provide more precise ages for fixing known stratigraphic horizons in the absolute time-scale; and particularly so when it is corroborated by the rubidium – strontium method.

The ages of the coarse-grained British granitic rocks have been determined by us on separated biotite (which is assumed to have complete retention of its radiogenic argon) by the argon – potassium method. An account of our analytical procedure and the detailed geological description of our samples will be published elsewhere. Argon was extracted from the mineral by heating to 1,500° C. in an induction furnace, and measured both volumetrically, and by the isotope dilution technique, using argon-36 as a tracer; there was agreement by both methods

Table 1

Sample	Stratigraphic position	Mineral	Method	Age (m.y.)	Ref.
A, Chinle Formation, Colorado Plateau	Upper Trias	Pitchblende	U–Pb	[a]200–210	14
D, Beryl Mt. Pegmatite, N.H.	[b]Upper Devonian–Carboniferous	Muscovite	A–K	324	12, 19
F, Franco–German Hercynian	Upper Dinantian or Namurian	Biotite	A–K and Sr–Rb	345	3
G, Georgia Piedmont	Permo-Carboniferous	Micas	A–K and Sr–Rb	360	13
O, Bentonite, Chattanooga Shale	Upper Devonian	Biotite	Sr–Rb	414 ± 45	15
P, Givetian of Saskatchewan	Middle Devonian	Sylvite	A–K	425	17
H, Bear River, Nova Scotia	Post-Lower Devonian	Biotite	Sr–Rb	370	8
			A–K	365	
M, Nictaux Falls, Nova Scotia	Post-Lower Devonian	Biotite	Sr–Rb	391	8
				410	
T, Boisdale Hills, Nova Scotia	[c]Post-Lower Devonian	Felspar	Sr–Rb	486	8
		Biotite			
I, L. Dubuque Formation, Minnesota	Upper-Middle Ordovician	Felspar	A–K	390	10
R, Bentonite, Stone Rivers Group, etc.	Middle Ordovician	Biotite	Sr–Rb	451–496 ± 50	15
B, Dartmoor granite	Post-L. Westphalian, pre-L. or M. Permian	Biotite	A–K	305	Ox.
C, Oslo Alkali Suite	Stephanian or L. Permian	Biotite	A–K	308	Ox.
E, Land's End granite	Post-L. Westphalian, pre-L. or M. Permian	Biotite	A–K	340	Ox.
S, Cairnsmore of Fleet granodiorite	Post-Silurian, pre-L. Carb.	Biotite	A–K	470	Ox.
U, Shap adamellite	Post-Silurian, pre-L. Carb.	Biotite	A–K	475–510	Ox.
N, Mynydd Mawr microgranite	Lower–Upper Ordovician	Felspar	A–K	410	Ox.
		(70 per cent retention		550)	Ox.

(*a*) This may not represent the age of the formation in which the pitchblende is found; (*b*) the stratigraphy is probably less precise than this (Kulp, private communication); (*c*) see ref. 8 for an alternative stratigraphy.

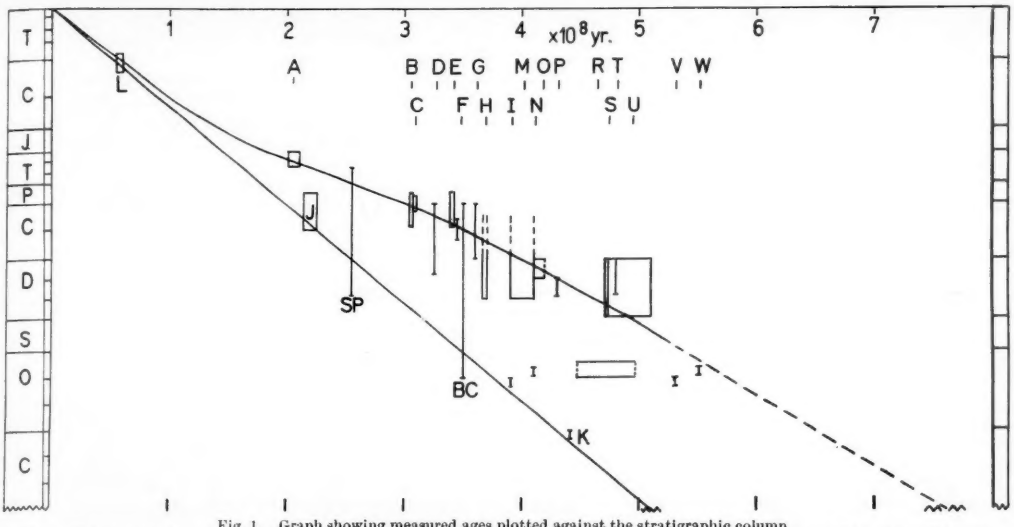

Fig. 1. Graph showing measured ages plotted against the stratigraphic column

Key. Holmes scale (on curves): *L* = Laramide orogeny; *J* = Joachimstal pitchblende; *SP* = Spinelli samarskite; *BC* = Bedford cyrtolite; *K* = Kolm

Other determinations:

A Chinle formation
B Dartmoor granite
C Oslo alkali suite
D Beryl Mountain pegmatite
E Land's End granite
F Franco-German Hercynian
G Georgia Piedmont
H Bear River, Nova Scotia
I Dubuque formation
M Nictaux Falls
N Mynydd Mawr microgranite
O Devonian bentonite
P Givetian of Saskatchewan
R Ordovician bentonite
S Cairnsmore of Fleet granodiorite
T Boisdale Hills, Nova Scotia
U Shap adamellite
V Dubuque formation, 70 per cent retention
W Mynydd Mawr, 70 per cent retention

All Oxford values estimated as ± 5 per cent, constants used being $\lambda_\beta = 0{\cdot}476 \times 10^{-9}$ yr.$^{-1}$; $R = 0{\cdot}123$.

The relative lengths of the geological systems are taken from the Holmes scale; the younger end of the curve is drawn to agree with data reported by Evernden (private communication).

within a few per cent. The reliability of the apparatus was checked by measuring the ages of previously determined samples obtained from the Department of Terrestrial Magnetism and by determining the argon content of atmospheric air. The atmospheric argon contamination and other possible impurities of the samples were checked mass spectrometrically. The precision and reproducibility of argon determination was better than 2 per cent. The potassium content was determined by flame photometry to approximately 2 per cent.

The results of our age determinations are given in Table 1. These samples have been chosen chiefly because their positions in the stratigraphic column are well defined. (We have found that other British granitic rocks belonging to the same petrographic provinces, but of doubtful individual stratigraphic assignment, give consistent results.) This has allowed us to draw the curve shown in Fig. 1, relating the geological age to the absolute age. In the past it has been customary in many cases to re-interpret any rather doubtful stratigraphy of samples measured, in order to fit them to the Holmes scale. Our results show a systematic divergence from this Holmes scale. In Table 1 we also give a number of published ages of samples for which the stratigraphy is less precise, in order to show their relation to our curve.

It is now seen that Faul's Hercynian ages, derived mainly from rubidium–strontium data, are compatible with the Dinantian–Namurian stages of the Carboniferous. The age values for Bear River and Nictaux Falls[8] would place these in the Devonian; field-evidence indicates that these granites intrude into lower Devonian[9], and so cannot be Ordovician as would be indicated by the Holmes scale. On our time-scale, the Boisdale granite was intruded into the early part of the Devonian.

Our age value of 410 m.y. for the Mynydd Mawr microgranite, which has been assigned to the Caradocian stage of the Ordovician, is to be compared with the measurements of Wasserburg and Hayden[10] on the upper-Mid-Ordovician Dubuque felspar. They dated this at 495 m.y.; which would be reduced to 390 m.y. if one uses the presently accepted nuclear constants in calculating the age. However, felspars are observed to have lost about 30 per cent of their radiogenic argon during their life-time[11], and allowing for this leakage both the Mynydd Mawr and Dubuque samples lie close to the new scale.

Damon and Kulp[19] have estimated the age of the Beryl Mountain formation, which is Upper-Devonian–Carboniferous[12], to be about 325 m.y., which agrees with the new scale. Measurements by Kulp and Long[13] of the metamorphic and igneous rocks of the Piedmont, using argon – potassium, rubidium – strontium and uranium – lead ratios, give an age value of 360 m.y. These were probably formed during the Permo-Carboniferous Appalachian orogeny, which places them on the new curve. Miller and Kulp[14] have reported that uranium – lead ratios of the Upper Triassic Chinle of the Colorado Plateau indicate an age of about 210 m.y.—once again higher than the Holmes Upper Triassic.

The recent measurements by Adams *et al.*[15] on an Upper Devonian bentonite lend further support to an extended scale. The value of approximately 410 ± 40 m.y. found from rubidium – strontium measurements is considerably higher than that which would be inferred from the Holmes scale; but it would fit well on the new scale. Two Middle Ordovician dates which they report fall roughly midway between the two scales.

The extended time-scale also has a bearing on the reported values of the diffusion coefficient of argon in

sylvites of known stratigraphic age. The work of Gentner and his collaborators[16] on Oligocene sylvites from Büggingen and Alsace indicates a value of $D = 1{\cdot}5 \times 10^{-19}$ cm.²/sec. at 40° C. This value has been criticized in detail by Folinsbee, Lipson and Reynolds[17] and Curtis and Reynolds[18], on the basis of measurements on an upper Middle Devonian (Givetian) sylvite. This sample had an apparent age of 285 m.y. from its argon-40 and potassium-40 content, while its true age was taken as 325 m.y. on the basis of the Holmes scale. Its deficiency in argon-40 was then explained by assuming loss by diffusion, with $D = 3 \times 10^{-20}$ cm.²/sec. However, using the Gentner value for D gives an age of 430 m.y. for this salt, placing it correctly in the Devonian in our scale.

An extension of the Holmes time-scale appears necessary to explain the results given here. Unfortunately, intrusive granitic rocks cannot be placed within narrow limits in the stratigraphic column; hence the large spread in the ordinate values of the plots on Fig. 1. It may be that the relative extent of any particular system in the column is in error, so that a good fit to a straight line is not to be expected. The method of estimating maximum thicknesses of sediments, especially in the earlier stages, is open to question. In this connexion it would be particularly desirable to have some unambiguous dates in the Ordovician and Cambrian. To define the extent of any system in detail it is clearly necessary to have the ages of materials, as, for example, lava flows, known to be from the beginning and end of the system. We do not consider that the biotites have inherited argon. Faul's rubidium – strontium ages were in agreement with his argon – potassium dates. The granitic rocks we have dated come from widely varying geological environments with differing contents of potassium, history and petrogenesis. Furthermore, Damon and Kulp[19] conclude from measurements on calcium micas that primary argon is not a significant source of error in the argon – potassium method of dating.

Some evidence has been brought forward in support of Holmes's scale, notably by Gentner and Kley[20], who gave figures for felspars from the Hercynian of south-west Germany; and also by several workers who have analysed glauconites (for example, Wasserburg *et al.*[10] and the group working on the subject at the Massachusetts Institute of Technology[21]). Gentner and Kley's results ranged from 306 m.y. to 237 m.y. for the intrusive rocks of the Hercynian orogeny, which, assuming no loss of argon, agree with the Holmes scale for the Lower Devonian to the Lower Carboniferous. We have, however, found that felspars retain only 70–90 per cent of their radiogenic argon in this age-range; and if such a percentage loss occurs in the German samples, they would be compatible with our scale. The suitability of glauconite as a mineral for the determination of age has yet to be proved, as glauconite is a very variable mineral species, usually extremely fine grained, of unknown genesis and easily subject to subsequent recrystallization.

We are grateful to Mr. C. McInnes for carrying out much of the experimental work. This project forms part of the programme on geological age and isotopes at present being carried out in the Department of Geology and Mineralogy, Oxford.

Note added in proof. Prof. J. L. Kulp now informs us that measurements made on Kolm material taken several miles from the sill, and hence not thermally altered by it, show a discordancy similar to that previously found (to be published shortly); and loss of radon by diffusion may account for some of this discordancy.

[1] Holmes, A., *Trans. Geol. Soc., Glasgow*, **21**, 117 (1947).
[2] Ahrens, L. H., *Geochim. Cosmochim. Acta*, **8**, 1 (1955).
[3] Faul, H., Ann. Rep. Director Geophys. Lab., Carnegie Inst., 168 (1956).
[4] Nier, A. O., *Phys. Rev.*, **55**, 153 (1939).
[5] Wickman, F. E., *Geol. Fören. i Stockholm, Förhandl.*, **64**, 465 (1942).
[6] Eckelmann, W. R., and Kulp, J. L., *Bull. Geol. Soc. Amer.*, **68**, 111 (1957).
[7] Cobb, J. C., and Kulp, J. L., *Bull. Geol. Soc. Amer.*, **68**, 1711 (1957).
[8] M.I.T., 5th Ann. Prog. Rep. for 1957–58 (1958).
[9] Bailey, L. W., Geol. Surv. Canad. Ann. Rep., **9**, 110 (1896).
[10] Wasserburg, G. J., and Hayden, R. J., *Geochim. Cosmochim. Acta*, **10**, 153 (1956).
[11] Goldich, S. S., *et al.*, *Trans. Amer. Geophys. Union*, **38**, 547 (1957).
[12] Cameron, E., U.S. Geol. Survey Paper 255, 349 (1954).
[13] Kulp, J. L., and Long, L. E., reported at 39th ann. meeting, *Trans. Amer. Geophys. Union*, **39** (1958).
[14] Miller, D. S., and Kulp, J. L., reported at 39th ann. meeting, Program Abstracts, Amer. Geophys. Union, 41 (1958).
[15] Adams, J. A. S., *et al.*, *Bull. Geol. Soc. Amer.*, **69**, 1527 (1958).
[16] Gentner, W., Prag, R., and Smits, F., *Geochim. Cosmochim. Acta*, **4**, 11 (1953).
[17] Folinsbee, R. E., Lipson, J., and Reynolds, J. H., *Geochim. Cosmochim. Acta*, **10**, 60 (1956).
[18] Curtis, G. H., and Reynolds, J. H., *Bull. Geol. Soc. Amer.*, **69**, 151 (1958).
[19] Damon, P. E., and Kulp, J. L., *Amer. J. Sci.*, **255**, 697 (1957).
[20] Gentner, W., and Kley, W., *Geochim. Cosmochim. Acta*, **14**, 98 (1958).
[21] M.I.T., 4th Ann. Prog. Rep. for 1956–57 (1957).

MARL: AN ANCIENT MANURE

By G. E. FUSSELL

ARTHUR YOUNG eulogized the custom of marling in 1769 in the following words: "All the country from Holkham to Houghton was a wild sheep walk before the spirit of improvement seized the inhabitants. . . . What has wrought these vast improvements is the marling; for under the whole country runs veins of a very rich soapy kind, which they dig up and spread upon the old sheep walks, and then by enclosing they throw their farms into a regular course of crops and gain immensely by the improvement"[1].

The process was well established when Young wrote the passage, and, according to his preface, had been initiated by Lord Townshend and Mr. J. Allen a good many years before. He made what might have been a more permanent record of this on his wife's tomb in Bradfield Combust church. Her obituary there states that she was the great-great-granddaughter of John Allen, Esq., of Lyng House in the county of Norfolk, the first person, according to the Comte de Boulainvilliers, who there used marl[2]. Only one farmer on the similar light land between Stoke and Thetford in Suffolk had bothered to use this method of improving his land in 1769. Much of the land in this area was then quite uncultivated, which surprised Young, because marl was to be found in many places beneath the sand[3].

The "Six Weeks Tour" was the first of Young's farming journeys, and was only incidentally concerned with agriculture. At that time he was inex-

perienced. He really knew little about the subject in which he was to achieve such great authority, and marling was new to him. He makes it clear that this method of reclaiming light land in part of Norfolk had been practised for some decades; but he does not give any explanation why John Allen first, and then Lord Townshend, should have begun to dig and spread marl if they, in fact, did initiate the process in that area. It may indeed have been something new there towards the end of the seventeenth century. More evidence is necessary to certify this, but it is quite certain that marl was used in other parts of the kingdom, and had been from at least the sixteenth century, and, possibly with some intermissions, from before the Roman occupation.

The word 'marl' has been used embracing a miscellany of earths dug out of the subsoil and spread upon the surface to increase fertility. Some of these subsoils have performed the function, notably clay spread on the fenland, but were not marl. Some typical marls, mixtures of chalk and clay, are derived from argillaceous limestones, such as some beds of Lias and Keuper. Marl containing carbonate of lime is far more valuable as a fertilizer than clay; it improves soil texture, adds carbonate of lime, potash compounds and sometimes phosphoric acid. Many light and blowing sands, like those that Young reported upon, have a bed of marl or clay near or beneath them, which can be readily obtained[4]. It is composed of a mixture of calcareous and other material in very varied proportions. Its precise definition is accordingly difficult.

The virtue of the material is said to have been recognized by the prehistoric Greeks, notably in Aegina, "where their use became a theme of mythology". Mineral fertilizers were found in their native states, either as earths like marl, or as deposits of alkaline salts like carbonate of lime, or nitrate of potassium (nitre), and mixing earths was first advocated by Theophrastus, according to Mrs. Semple. (She gives a modern interpretation, for I understand the Greek chemists did not know nitre.) It had the results set out by Sir Daniel Hall three millennia later. The Aegina surface stratum was a poor freshwater limestone underlaid by a stratum of fertile marl, which was dug out and laid on the surface to form a soil. The same thing was done in nearby Megara. Again, marl was a component of Tertiary Terraces[5].

Pliny, who disliked soil mixing, that is, sand on clay or clay on sand, confirms the use of marl in Megara, a marl-like white clay, and mentioned the different sorts by colour used in Britain and Gaul. They were the white, red, dove-coloured, etc. These were of two different qualities, acrid and fat. The white, often dug from deep pits, was that chiefly used in Britain. He made a distinction between that suitable for corn and for fodder crops, and estimated a rather exaggerated benefit lasting as long as eighty years. There was, however, no marl in Italy, and the Romans knew nothing of its use by experience. Varro, too, remarked the use of marl, a white fossil clay, as a fertilizer in Transalpine Gaul—*ubi agros stercorarent candida fossicia creta*—which Mr. Storr-Best had no doubt was the *Marne*, a natural mixture of lime and clay still used in France in 1912, and identical with the material used by the Greeks. Columella's uncle used it on his farm near Cordova, in Spain[6].

Between the fall of Rome and the thirteenth century there is a gap in the evidence. Whether marl continued to be dug and used in England during the centuries between is not known to me: but it is probable that it was used in France, and especially in Flanders. Oddly, it was on the clay lands there that marl was spread regularly and with excellent effect, because wet clay easily becomes sour, especially when the surface is little disturbed as in cereal growing. It was therefore necessary every few years to bring a heavy calcium concentration to these soils to neutralize the acidity. This was achieved by marling, which Lindemans justly describes as a remarkable piece of agricultural empiricism by a people who possessed no inkling of modern chemistry, but is quite contrary to the later English jingle:

> He who marls sand
> May buy the land;
> He that marls moss
> Suffers no loss;
> He that marls clay
> Throws all away.

In the Belgian sand land there is no early mention of marling, but the Flemish clay lands frequently have field names including marl and pits from which marl could have been dug before the end of the Middle Ages. Tenants in the area between Leuwen and Haspengouw were obliged by their leases to spread marl every so often, and the obligation continued. In other places marl was a complement, but not a substitute, for stall manure. The use of the material may have declined here with the increased production of stall manure, which it influenced indirectly by affording better yields of straw and fodder crops, but tenants who had insufficient dung were required by their leases to use it until the seventeenth and even the eighteenth century[7].

The open fields in Great Britain contained many disused marl pits in the early sixteenth century[8], and these may have been some centuries old. Walter of Henley was a protagonist of the manure in the thirteenth century. He thought the effects of marl lasted longer than that of manure, and indeed of earth and manure mixed, which was better than the simple dung. He advised spreading marl on the ground of the sheep fold every fortnight, and the anonymous "Seneschaucie", of about the same date, required the bailiff to "cause the land to be marled, folded, manured . . . as his knowledge may approve". The wagoner, too, ought to know how many times in the day the horses could go to carry marl or manure to the fields; some of this was repeated in "Fleta"[9]. These books can only be accepted as reflexions of the best practice of their day. They can scarcely have been speculative or imaginative works like those of so many of the later book-farmers, though it is possible they owed something to classical writings. Consequently, some medieval farmers in England were acquainted with the use of marl, and their use of the material was the cause of the disused marl pits noticed by Fitzherbert. He, too, was doubtless well read in such versions of the classical authors as were then available, and his ideas influenced by them. This must have been a pertinent reason why he deplored the stupidity of some early sixteenth-century farmers who neglected marl.

There was what seemed to them a sound economic reason for their action. They would not improve their land by this or any other process because they feared their landlords would demand higher rents immediately higher yields were gained. This was rather a silly line of reasoning; but no doubt it seemed prudent to them. Fitzherbert was convinced that marling well done would last for twenty years[10].

No doubt Fitzherbert had travelled through parts of England, and was well equipped to make accurate agricultural observations on what he saw. His statement that few open arable fields were then manured with marl is by so much to be accepted, but when Leland was in Shropshire, Cheshire and Lancashire, he found marl was used for ameliorating the poor sandy soils in those three counties, and he names specific places where the results were good[11]. Since these were counties where the convertible husbandry was practised in some places, that is, grass was ploughed for a few years cropping and then returned to ley, marling may have been continued from old times, or only been intermittently interrupted. It was certainly usual, not only in these three counties, but also in Somerset, Middlesex, Sussex and Surrey by the end of the sixteenth century[12], and this leads to the conclusion that it may have been habitual, almost traditional, in these areas.

Gervase Markham, writing in the first quarter of the seventeenth century, was a real enthusiast for marl. He recalled Pliny's statement that the Britons used it, and that it was mentioned in books of gainage or husbandry written in the reign of Edward II as well as by Walter of Henley. Markham himself describes how it was used by Kentish farmers when bringing areas of wealden land into cultivation. The quantity of marl used varied widely on different soils —as was wise. Marl was not, he said, good on clay land. On sandy or hazelly land 500 cartloads, containing 10 or 12 bushels each, could be usefully spread. The Kentish acre was 160 rods of 16 ft. After applying the marl, this land might be ploughed up and wheat sown, but some farmers broke up the grassland and took a crop of oats as was sometimes done during the recent war-time ploughing-up campaign. After this they spread the marl and sowed wheat. Land treated in this way must not be harrowed down fine. Only one or two crops were taken, and then it was let fall down to grass for five or six years. Markham rather optimistically said that "all this time it will beare a very good and sweet Pasture, well set with a white Clover, or, three leav'd grasse, most fatning and profitable, both for Sheepe and Bullocks". When the appropriate time had passed the ley was broken up again for two or three years crops. Under this system the effects of marling could be enjoyed for some thirty years, but if too many crops were taken it would be exhausted in five years. Was this the system employed elsewhere in the country where marl had continued to be used ? Very probably it was.

Four sorts of marl were found in the Weald, distinguished by their colour, grey, blue, yellow and red. Their order of merit was blue, yellow, grey, red. All were good material if as slippery as soap[13].

Whether marl continued to be used in France from the time when the practice was first observed by Cæsar's soldiers or not is difficult to say, but it seems probable. When Estienne and Liebault wrote their "Maison Rustique" in the sixteenth century they spoke of manure as either rotten dung or marl, and advised that the dung or marl be spread in the increase of the moon about November 18. Bernard Palissy, too, whose knowledge of soils was acquired during his researches into the best kind of clay for making pottery, included in his "Discours admirables" a chapter on marl, its value, how to recognize and where to find it. The familiarity with which these and other French writers deal with the use of marl suggests that it was generally used by French farmers when they were fortunate enough to find it[14].

Throughout the seventeenth century the English didactic writers continued to advise the use of marl, and the best way of doing so. Hartlib recorded that the men of Essex called the scourings of their ditches marl in the same way as pond mud was called 'Marle de mare' in a Waalse lease. Blith was sufficiently interested to carry out what must surely be one of the first comparative experiments in fertilizers. He used marl, pond mud, dung, and folk mucked two or three lands with each, and even had a control plot untreated. Of course he did not record the resulting yields arithmetically, but found the marl compared favourably with the other treatments, and fertilized nine years crops[15]. When the nascent Royal Society made its Georgical inquiry just after the Restoration it included in its questionnaire an exhaustive demand for information about the availability of marl, its depth, colour, the soils upon which it was used, and in what quantity, what time of year it was applied, and the crops which succeeded best on the land treated. How long its effect lasted was also asked, a question answered very variously from classical times onwards, but in his examination of the surviving returns Mr. Lennard does not say whether these questions were answered by any of the Society's correspondents. Unfortunately the Society was unable to secure a complete set of replies; but those that remain show that marl was then used in widely separated parts of Britain. In the Liberty of Ripon "Clay, Moorish and cold weeping grounds" were marled when broken for arable at 240 Winchester bushels the statute acre. Less was applied in other parts of Yorkshire, for example, in the Holme Beacon district. Marl was used in Devon and Cornwall as well as sea sand full of calcareous shells. Very heavy dressings were given in the "marl district" of Devon. Meadow land was marled in Wharfedale[16]. Evelyn had no doubt that relenting chalks or chalk-marl was a profitable fertilizer, and John Clayton informed the Royal Society that the tobacco growers of Virginia used only cow dung, although he had observed both red and blue marl at some breaks in the hills. In France, too, Louis Liger was a strong protagonist of marl, which was the best manure. Heavy dressings of 1,000–1,200 *voies* per arpent were given. The work was done in June or November, and, as elsewhere, the marl was left lying on the surface during the following winter so that it might be crumbled by sun, rain, snow and frost[17].

Even in Norfolk marling was being extensively practised by 1706, and had been on the Raynham Estate throughout the late seventeenth century. In 1731, at Holkham, 2,096 loads of marl were spread. Miss Naomi Riches supplies an ingenious explanation of the reason why it has been so often said that marling was abandoned from time to time and rediscovered[18]. The effects of the heavy dressings of marl were said to last for generations, from twenty to fifty, or eighty and a hundred years. Whether they did so is another question ; but the result of the long intervals that elapsed after a dressing of marl had been spread was that the new generation of farmers always regarded the process as one practised by its forefathers, and not presently current. Marling had therefore to be constantly revived. This is perhaps the explanation why it seemed so new and remarkable to Arthur Young, and that he and the Comte de Boulainvilliers thought it had been revived by Mrs. Young's great-great-grandfather, Mr. Allen.

On the Continent marl does not seem to have been subject to these intermissions. In Flanders it was superseded by the careful conservation of increased supplies of stall manure and animal urine plus town sewage and industrial waste, like rape cake. The reclamation of sandy lands was continued well into the nineteenth century, and was achieved by breaking through the iron pan beneath the sand, digging out the subsoil, stated to be "a stratum of loam", and spreading it upon the surface[19]. There was probably a mixture of calcareous material in this loam, but whether it was what we should call marl or not, I do not know.

The later history of the use of marl in England can be compressed into a paragraph. Throughout the eighteenth century the material was highly commended and extensively used at least by some farmers in many parts of the country. Change began with the introduction of bone manure, which soon began to supersede marl in Cheshire and the West Midlands. Early in the nineteenth century farmers were filling in the old marl pits and levelling the ground to increase the surface area of their farms. This was the beginning. The coming of manufactured and imported mineral fertilizers in the mid-nineteenth century did away with the need for the heavy labour involved in digging, carting and spreading marl, and the practice was abandoned once more, probably finally.

[1] Young, Arthur, "Six Weeks Tour", 2nd ed., 21, 22 (1769).
[2] Young, Arthur, "Six Weeks Tour", 2nd ed., viii (1769). "A Virginia Farmer", "Roman Farm Management", 83 (1913).
[3] Young, Arthur, "Six Weeks Tour", 2nd edit., 48 (1769).
[4] Hall, A. D., "The Soil. An Introduction to the Scientific Study of Plant Growth", 30, 232, 233, 256 (1903).
[5] Semple, Ellen Churchill, "Geography of the Mediterranean Region: its Relation to Ancient History", 380, 414 (1932).
[6] Pliny, "Nat Hist.", 17, 4, 7. Varro, 1, 7. Bradley, R., "A Survey of the Ancient Husbandry", 65, 66 (1725). Dickson, Adam, "Husbandry of the Ancients", 1, 344 (1788). Storr-Best, Lloyd, "Varro on Farming", 29 (1912). "A Virginia Farmer", 83.
[7] Lindemans, Paul, *Geschiendenis van de Landbouw en België*, 1, 43 (1952).
[8] Fitzherbert, "Surveying" (1523), in "Certain Ancient Tracts concerning the Management of Landed Property Reprinted", 82 (1767).
[9] Cunningham and Lamond (eds.), "Walter of Henley's Husbandry", 21,31,91,111 (1890). Cripps-Day, F. H., "The Manor Farm", 60, 70 (1931). cf. Lodge, Rev. Barton (ed.), "Palladius on Husbandrie" (M.S. of about 1420 A.D.). E.E.T.S., 28 (1873).
[10] Fitzherbert, "Surveying" (1523), in "Certain Ancient Tracts concerning the Management of Landed Property Reprinted", 82 (1767).
[11] Cited in Darby, H. C., "Historical Geography of England before 1800", 346 (1936).
[12] Norden, John, "The Surveyor's Dialogue", 227 (1607).
[13] Markham, Gervase, "Inrichment of the Weald of Kent" (1625), *passim*. cf. Markham's "Farewell to Husbandry" (1638).
[14] See translation of Surflet, Richard, "Maison Rustique or the Countrey Ferme", 669, 670 (*c.* 1600). This book first appeared in France in 1569. Sarton, G., "Six Wings: Men of Science of the Renaissance", 167 (1958).
[15] Hartlib, "Legacie", 3rd ed., 34 (1655). Lindemans, *op. cit.*, 48. Blith, Walter, "English Improver Improv'd", 138 (1653).
[16] *Phil. Trans. Roy. Soc.*, 1, 91, 94 (July 3, 1665). Lennard, Reginald, "English Agriculture under Charles II", *Econ. Hist. Rev.*, 4, i, 32 (1932).
[17] Clayton, John, *Phil. Trans. Roy. Soc.*, 17, 984 (1693). Liger, Louis, "La Nouvelle Maison Rustique", 3rd ed., 1, 518 (1721).
[18] Riches, Naomi, "The Agricultural Revolution in Norfolk", 78 (1937).
[19] "Outlines of Flemish Husbandry", in vol. 3, "Husbandry" (Library of Useful Knowledge), 12 (1840). This follows van Aelbroek, "Agriculture de la Flandre" (1830), and is in turn followed by Rham, W. L., "On the Agriculture of the Netherlands", *J. Roy. Agric. Soc. Eng.* (1841, 1842).

SCIENCE AND TECHNOLOGY IN THE UNIVERSITY OF BRISTOL

OPENING OF QUEEN'S BUILDING

ON December 5, H.M. the Queen opened and named Queen's Building, which is to house the four Departments of Engineering, Civil, Mechanical, Electrical and Aeronautical, together with the Departments of Geology, Mathematics and Theoretical Mechanics in the University of Bristol.

Though the number of students concerned has been relatively small, the teaching of engineering and applied science in the University of Bristol has always been strong. Even before the days of University College, such men as William Smith, a founder of modern geology, John McAdam, the father of English roads, and Isambard Kingdom Brunel worked long in the district and influenced the rising generation towards careers in engineering. As a result, when University College was opened in 1876 it attracted to its staff young engineers and scientists of unusual calibre. Hele-Shaw and Stanton, both appointed before 1900, later became national figures in engineering, and the latter, as Sir Thomas Stanton, created the Engineering Division of the National Physical Laboratory. Silvanus P. Thompson, appointed for both "physics and electrotechnics", became a leader both in engineering education in London and in electrical engineering. W. J. Sollas, later translated to Trinity College, Dublin, and then to Oxford, was an outstanding geologist of international reputation. Between the World Wars there were among the engineering professors, Andrew Robertson and A. J. S. Pippard, both happily still very active. To this period belong also S. H. Reynolds and A. E. Trueman, who brought to geology a width of outlook and depth of local knowledge that made Bristol with its natural local advantages for geological field-work a well-known centre for the study of geology. In these inter-war years, also, the late H. R. Hassé, who was distinguished for his work in relativity theory and molecular physics, built up the Department of Mathematics from its early beginnings.

When Bristol received its charter in 1910, the Engineering Department of University College and the senior staff of the Technical College which had been maintained for many years by the Society of Merchant Venturers were brought together to form the Faculty of Engineering. It was housed in the buildings of the Technical College in Unity Street and was presided over, first by Dr. Wertheimer, and later by Prof. Andrew Robertson, as principal of the Merchant Venturers' College and dean of the Faculty of Engineering in the University. This arrangement was a source of strength to the Engineering Departments of the young University, but as time went on it was found unsatisfactory for the staff to attempt to cover the teaching of technicians and university students; also the laboratory space available was cramped and unsuitable for university work, with its increasing emphasis on research. While the University staff was freed from teaching in the Technical College in the years between the Wars,

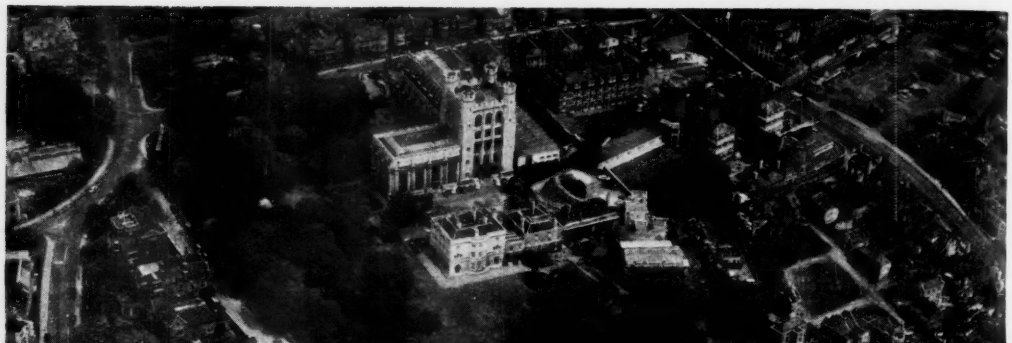

Photo: *Aerofilms Ltd.*

Fig. 1. Queen's Building, University of Bristol

and in the same period much first-class engineering research was produced, it is a matter for congratulation that the University, after forty years of invaluable help from the Society of Merchant Venturers, now has its Faculty of Engineering housed in the midst of the other University departments on an incomparable site, and in a building which gives the staff all the facilities they could desire for both teaching and research. The number of undergraduates now reading technology in Bristol is just under 350. It is to be hoped that with the opportunities now available the number will grow rapidly.

Queen's Building (see Fig. 1) stands on the southern brow of St. Michael's Hill just below the H. H. Wills Physics Laboratories. It has a commanding view over the city and docks of Bristol to the Somerset hills beyond. Construction was started almost nine years ago, and so goes back to the difficult days when labour and materials were in short supply. There is little to indicate this, apart from the fact that the framework of the building is of reinforced concrete, which gives a heaviness to many of the interior vistas. Some will find this pleasing, but it is a little out of keeping with the spirit of structural research in aeronautical and other fields, which has been during the past three decades, and still is, such a feature of Bristol engineering. The structure is lightened where possible by metal partitions and floor openings dictated by the specialist needs of the various departments. It was appropriate that in 1949 the first sod should be cut, incidentally using a mechanical excavator, by Prof. Andrew Robertson, at that time the dean of the Faculty of Engineering. It is very largely due to his outstanding work for the University over a period of thirty years, to his zeal and planning ability that the building exists to-day. With him was the architect, Sir George Oatley, senior partner of the Bristol firm of Oatley and Brentnall, which had been responsible for many Bristol buildings, including the University Tower and Library. Upon Oatley's death shortly afterwards, all the burden of architectural work fell upon his partner, Mr. Ralph H. Brentnall. Two Bristol contractors, John Perkins and Son and William Cowlin and Son, were responsible for the construction, the first for the preparatory work on the site and the second for the superstructure.

As will be seen from the accompanying photograph (Fig. 1), the building consists essentially of a large structure around an elongated courtyard, with two wings running from it east and west. It was the west wing and the western half of the central block that were constructed first. As soon as the foundation works for these had reached the centre of the building, the foundation stone to be seen beside the main entrance was laid on December 14, 1951, by Sir Winston Churchill, chancellor of the University, and at that time Prime Minister. The westerly parts of the building were completed in 1954 and at once taken into use, while work proceeded on the remainder of the central structure and on the east wing. At the same time, the Library building set on the hillside immediately before the southern front of the central structure was begun. It was finished in 1957 and the remainder of the work in 1958.

The building is approached by way of University Walk, with the gardens of the Royal Fort on the left and the Baptist College on the right. The main entrance leads directly to a spacious entrance foyer, in which will be noticed a plaque recording the special connexion between the Society of Merchant Venturers and the Faculty of Engineering. Like the walls around the entrance foyer, it is of gris mouchette, a marble-like limestone from northern France. The exterior is faced with a light-coloured brick from Cheshire with the principal features in Bath stone. Of the three main floors in the building, the lower ground floor is devoted to engineering laboratories: mechanical engineering in the west wing, aeronautical engineering in the east wing and civil engineering in the centre, with an additional laboratory under the Library. The ground floor, on the level of the main entrance, houses electrical engineering in the west wing and part of the centre, and the Department of Geology in the east wing. From the lower floors there is access to the Library which, with its gallery above, and stack room below, houses some 10,000 volumes and is designed to accommodate many more. On the first floor, lecture theatres and staff rooms occupy the centre block, with drawing offices, lecture rooms and tutorial rooms in the wings. At this level, also, the Departments of Mathematics and of Theoretical Mechanics are housed; the former, which serves the University as a whole, occupies much of the lecture room accommodation in the east wing, and the latter, which works primarily with the engineering departments, uses rooms in the west wing.

Further staff rooms are provided in a second floor which extends along the middle part of the building. Here also are some of the rooms set apart for post-graduate students.

It will be seen that the building gives all the departments within it new opportunities for extending or improving their equipment for both teaching and research purposes. In the field of civil engineering, the range of apparatus for the strength-testing of structures has been extended, and provision made for dynamic as well as static testing; and facilities for work on hydraulics and soil mechanics have been much improved. Better workshops, extended facilities for material and fatigue testing, and provision for the testing of gas turbines have become possible in the new mechanical engineering laboratories. The electrical engineering laboratories, in addition to extended testing equipment for general purposes, now provide several specially designed generator sets, which are the basic tools needed for research into problems in dynamo-electric machinery. The Department of Aeronautical Engineering, which owes much to the generosity of the Bristol Aeroplane Company in founding the Sir George White chair of aeronautical engineering some years ago, has several low-speed wind tunnels in operation, and more are planned. Compressors and a large high-pressure air reservoir are installed to provide for the operation of transonic and supersonic wind-tunnels. The Department of Geology has now adequate space for the display of its extensive collection of geological specimens, and has extended its laboratory work generally. All the Departments have been able, in addition to their teaching laboratories, to set aside proper space for research work.

There is no doubt that the provision of Queen's Building should enable Bristol to make an even greater contribution than it has in the past to the highly important field of technology and applied science.

J. F. BAKER

OBITUARIES

Prof. E. J. Maskell, F.R.S.

By the death of Ernest John Maskell on December 20 plant physiology in Britain has lost one of its most distinguished exponents.

Born in Cambridge on February 1, 1895, Maskell was educated at Cambridge County High School and the University of Cambridge, where he was a member of Emmanuel College. He graduated in 1919. With the award of the Frank Smart Studentship in 1920 he undertook research in plant physiology under the late F. F. Blackman. The results of this work on the diurnal rhythm of photosynthesis in leaves of cherry laurel in relation to carbon dioxide concentration, and on rates of photosynthesis in relation to stomatal opening, were afterwards published in the *Proceedings of the Royal Society*. After an appointment in 1922 to the Horticultural Research Station at Cambridge and a period at Rothamsted Experimental Station (1924–26), Maskell was appointed as plant physiologist at the Cotton Research Station in Trinidad. It was here, during 1926–30, that in conjunction with T. G. Mason he carried out the work by which he is best known and by which he is likely to be chiefly remembered, on translocation of carbohydrates, nitrogenous substances and phosphorus, potassium and calcium compounds in the cotton plant.

By 1930 Maskell's outstanding quality as an experimental plant physiologist was well realized and he was recalled to Cambridge to take up a lectureship, which was later raised to the post of reader in plant physiology. Here in the Cambridge Botany School for twenty-one years he was an inspiration to the many research students from Britain and overseas who had the advantage of his direction and supervision.

In 1951 Maskell was appointed to succeed me in the Mason chair of botany in the University of Birmingham. Just before his death he had been engaged in the troublesome task of developing plans for a new Botanical Department of the University.

Maskell was elected a Fellow of the Royal Society in 1939 and served on the Council of the Society during 1951–53. He was a member of the Agricultural Research Council during 1952–57 and represented the University of Birmingham on the governing body of Studley College from 1951 until his death. He was also a member of the governing body of the Grassland Research Institute, Hurley, a member of the executive committee of East Malling Research Station, of the Scientific Advisory Committee of the Empire Cotton Growing Corporation, and of the Advisory Panel of the Indian Tea Research Association.

Maskell was a life-long and active member of the Society of Friends and during the First World War served with a Friends Ambulance Unit. He was the most upright and kindest of men and those who had the privilege of his friendship held him in the highest

regard. He married in 1923 Elisabeth Rose McCormick, who survives him. WALTER STILES

Prof. N. J. Scorgie

PROF. N. J. SCORGIE, Courtauld professor of animal husbandry in the Royal Veterinary College, London, died suddenly in his fiftieth year on February 10, 1958, in Iran, where at the instigation of the Food and Agriculture Organization of the United Nations he was conducting a mission related to re-organization and development of animal husbandry services. Jack Scorgie, as he was commonly known, was a 1929 arts and 1931 science graduate of Aberdeen, after which he took his veterinary diploma at the Royal Veterinary College and then joined the staff of that Institute. Following preliminary work in the Pathology Department and in preventive medicine, he transferred to the Department of Animal Husbandry, where he worked under Prof. W. C. Miller, whom he succeeded in 1946.

Scorgie had made the most of his wide training and was beginning to reap the benefit of his labours in organizing his Department, partly in new quarters, at the time of his death. He will be remembered best for his work on trichomoniasis in cattle, housing problems and poultry husbandry, being with the late Dr. Black, of Reading, the first to report on the successful applications of artificial insemination in fowls (*Gallus domesticus*).

NEWS and VIEWS

Plant Physiology at the Imperial College of Science and Technology : Prof. Helen K. Porter, F.R.S.

DR. HELEN K. PORTER, who has recently been appointed to the chair of plant physiology in the Imperial College of Science and Technology, London, is the first woman to hold a chair in the College. After graduating from Bedford College, London, in 1921, she spent a year in the Department of Organic Chemistry at the Imperial College, and was then appointed research assistant in the Department of Botany. Ten years later she joined the staff of the Research Institute of Plant Physiology attached to the Imperial College, and concentrated primarily on research in the field of carbohydrate metabolism. Shortly after the Second World War she spent a year in Washington University, St. Louis, studying enzymological methods. The subsequent development of her work, in collaboration with a group of colleagues and postgraduate research students with the support of the Nuffield Foundation, led to the opening in 1953 of an enzymology laboratory in the Institute of Plant Physiology, to accommodate a research group under Dr. Porter's direction. In 1956 she was elected to Fellowship of the Royal Society. In 1957 Dr. Porter was appointed to a new readership in enzymology at the Imperial College.

Burden Neurological Institute : Prof. F. L. Golla

PROF. F. L. GOLLA, director of the Burden Neurological Institute, Bristol, since 1939, is to retire. Prof. Golla, who followed Sir Frederick Mott as director of the Central Pathological Laboratory at the Maudsley Hospital, London, has for many years been a leading figure in neuropsychiatric research. Primarily a physiologist by training, his interests have extended into endocrinology, biochemistry, pharmacology and psychology, while his medicine has been constantly refreshed by gleanings in the German, French and Italian literature. His erudition is immense. In 1939 Prof. Golla moved to Bristol to start the Burden Neurological Institute, which, under his direction, has become widely known throughout the world.

Of Prof. Golla's research achievements, one of the most remarkable was his early application of the electroencephalograph to the study of neurological and psychiatric disorders, and, ably assisted by Dr. Grey Walter, he established the diagnostic value of the technique in cases of cerebral tumour and other lesions of the brain. He was also a pioneer in attempting the surgical treatment of epilepsy by the removal of epileptogenic foci, and played an important part in the development of electro-convulsive therapy. Many generations of students at the Maudsley Hospital remember with gratitude the inspiration of his lectures on the physiology of the nervous system. He has a style of his own and combines a keen critical capacity with a breadth of vision that is unique. In 1950 there appeared a volume entitled "Perspectives in Neuropsychiatry", which was published by old pupils and colleagues as a present for Prof. Golla's seventieth birthday. Always full of new ideas, he has found his pleasure and inspiration in his work and cares little for publicity or personal rewards.

Dr. W. Ross Ashby

DR. W. ROSS ASHBY, who now succeeds Prof. Golla, was previously director of the Research Laboratory at Barnwood House, Gloucester. He was educated at Cambridge and St. Bartholomew's Hospital and was at one time engaged as a pathologist at the Watford Peace Memorial Hospital and as a house physician at Bethlem. He is probably best known for his work on the 'homeostat', an electronic device designed to parallel the homeostatic mechanisms of the brain. His interest in the behaviour of neuronal nets led to the writing of the book, "Design for a Brain", which is very widely known.

Bell Telephone Laboratories Appointments : Dr. James B. Fisk

DR. JAMES B. FISK, executive vice-president of the Bell Telephone Laboratories, has been elected president as from January 1. Dr. Fisk succeeds Dr. Mervin J. Kelly, who has been elected chairman of the board of directors. Dr. Kelly has served as president of the Laboratories since 1951. Mr. Estill I. Green, vice-president in charge of systems engineering, is to be executive vice-president as from January 1.

Dr. Fisk, who has been associated with the Bell Laboratories for nearly twenty years, has combined a distinguished career in industrial research with outstanding service to the Government in the field of science. He was director of the Division of Research of the Atomic Energy Commission in

1947–48, and Gordon McKay professor of applied physics in Harvard University during 1948–49. He also served for six years on the General Advisory Committee of the Atomic Energy Commission. He is vice-chairman of President Eisenhower's Science Advisory Committee and has served on other government committees. He is a member of the U.S. National Academy of Sciences. He joined the technical staff of the Bell Laboratories in 1939, and during the Second World War he headed the Bell Laboratories group engaged in developing microwave magnetrons for high-frequency radar. After the War he was in charge of electronics and solid-state research.

Dr. M. J. Kelly

Dr. Kelly is one of America's leaders in the field of industrial research. He began his Bell System career in 1918 as a research physicist with the research division of the Western Electric Company's engineering department. This department was later incorporated as the Bell Telephone Laboratories. After serving as director of vacuum tube development and as development director of transmission instruments and electronics, he was elected director of research in 1936. He became executive vice-president in 1944 and president of the Laboratories in April 1951. He has had wide experience not only in research and development programmes relating to communications, but also in projects for the Armed Forces. In the course of the Second World War, the Bell Laboratories were devoted almost completely to military research and development programmes, all of which were under Dr. Kelly's guidance, and he was awarded the Presidential Certificate of Merit. Since the War he has held many public service appointments in Washington, particularly with the Atomic Energy Commission, the Department of Commerce and the Department of Defense. He is a member-at-large of the Defense Science Board. He has been awarded the James Forrestal Memorial Award of the National Security Industrial Association and will receive the 1959 John Fritz Medal for "his achievements in electronics, leadership of a great industrial research laboratory, and contributions to the defense of the country through science and technology". Dr. Kelly is also active in the field of education. He is a life member of the Massachusetts Institute of Technology Corporation and a member of its Executive Committee; a trustee of Stevens Institute of Technology; and serves on advisory committees at M.I.T., New York University, Case Institute of Technology, Columbia University, and the New York City Board of Education. He is a member of the New York City Health Research Council, a trustee and member of the corporation of Atoms for Peace Awards, a trustee of the Alfred P. Sloan Foundation and a member of the U.S. National Academy of Sciences.

Mr. E. I. Green

Mr. Green has a long record of distinguished engineering experience and achievement, including more than seventy patents granted for his inventions. He is also the author of many articles on scientific and personnel subjects. He began his career in 1921 with the American Telephone and Telegraph Company's development and research department, and with that department transferred to the Bell Laboratories in 1934. For many years he specialized in planning the development of new transmission systems, and services and facilities for special customers. During the Second World War he was engaged in development work on radar testing apparatus and other electronic equipment. He was appointed director of transmission apparatus development in 1948 and headed the development of systems components, including electronic components for transistorized systems. In 1953 he was elected director of military communications systems, in charge of planning and development in that area. He became vice-president of the Bell Laboratories in charge of systems engineering in June 1955. In that post he has been responsible for all Bell Laboratories work related to the systematic analysis and planning of future communications developments and systems.

The Royal Society: Tercentenary Celebrations

On November 28, 1660, a group of originally minded men meeting together in the City of London decided to form themselves into a scientific society. King Charles II, being informed of this, constituted himself the formal Founder, and the new society, now the premier scientific society in the world, came to be known as the Royal Society of London, or more generally, 'The Royal Society'. The Society, the apartments of which are now in Burlington House, Piccadilly, announces that it proposes to celebrate the tercentenary of its foundation during July 18–26, 1960, and a committee, with Sir Cyril Hinshelwood, president, as chairman, has begun to arrange appropriate celebrations to mark this event. Leading scientists from all nations are expected to attend the meetings, which are to include special visits to the City of London and the Universities of Oxford and Cambridge, both of which have important links with the Society's development over three centuries. The members of the Committee are: Sir Cyril Hinshelwood (*chairman*), Lord Adrian, Sir Gavin de Beer, Prof. P. M. S. Blackett, Sir Lawrence Bragg, Sir Lindor Brown, Sir Charles Dodds, Sir Alexander Fleck, Sir Howard Florey, Prof. W. V. D. Hodge, Sir Harry Melville, Sir William Penney and Dr. H. G. Thornton. The secretary to the Committee is Dr. D. C. Martin (assistant secretary of the Royal Society).

Nuffield Collection of Meteorites at the British Museum (Natural History)

A substantial part of Dr. H. H. Nininger's collection of meteorites, consisting very largely of falls hitherto unrepresented in British collections, has been purchased for the British Museum (Natural History) through a gift of £50,000 from the Trustees of the Nuffield Foundation, to celebrate the centenary of Prof. N. Story-Maskelyne's appointment as first keeper of minerals. To the 837 falls hitherto represented in the Museum, the Nuffield purchase adds a further 197, bringing the total to 1,034, or about 67 per cent of all known falls. Together with the 72 additional specimens of falls already represented, this greatly strengthens the reserves available for further exchanges. This large accession of meteorites is to be known as the Nuffield Collection. The British Museum's collection of meteorites is the largest and among the oldest in the world, dating back to 1776 when a specimen of the stony-iron found at Krasnojarsk, Siberia, was presented by the Russian Academy of Sciences. For many years the collection remained a relatively minor one, until Prof. N. Story-Maskelyne became the first keeper of minerals in 1859. A judicious series of exchanges and purchases soon improved the status of the collection, and when

G. T. Prior published his "Catalogue of Meteorites" in 1923 it held a clear lead over all others. In the past thirty-five years, the intensive search for meteorites sponsored by Dr. H. H. Nininger in the United States has resulted in a large number of new finds, but has also made the acquisition of new falls by purchase increasingly difficult for the Museum. Although a programme of exchanges with other museums has been vigorously pursued, the increase in falls represented in the British Museum has hitherto not kept pace with the increase in known falls. The scientific aspect of the Nuffield gift is of importance because meteorites constitute the only extra-terrestrial material available for detailed study, and an exact knowledge of their composition and structure is important for the cosmogony of the solar system.

Skomer Island as a Nature Reserve

With the co-operation of the West Wales Field Society, the Nature Conservancy is purchasing the island of Skomer as a National Nature Reserve. Skomer, 722 acres, is the largest of the islands off the Pembrokeshire coast. It is the landward edge of the ridge of varied igneous rocks of Ordovician age, jutting west from the mainland through Skomer to form Grassholm (famous for its colony of 10,000 pairs of gannets). Each year great numbers of sea-birds breed on Skomer, as well as a strong colony of the Atlantic grey seal. Probably the most notable breeding species is the Manx shearwater, a bird scarcely found on the mainland, but nesting in tens of thousands on Skomer and Skokholm. The puffin colony is, next to that of St. Kilda in the Hebrides, probably the largest in the British Isles. The island is also well known for the Skomer vole, which differs from the common bank vole in its larger size, extreme tameness and brighter colour. Skomer is being leased to the West Wales Field Society, which made an extensive field survey of the island in 1946, described in "The Island of Skomer" (West Wales Field Society, Orielton, Pembroke, 1950. 18*s*.). Persons requiring facilities on the island should communicate in advance with the Society, c/o The Hon. Warden, Orielton, Pembroke. Scientific investigations on the reserve may be arranged with the Regional Officer for South Wales of the Nature Conservancy, Department of Zoology, University of Swansea, Singleton Park, Swansea.

The British Steel Industry

Political and Economic Planning has rendered a real service by summarizing in Broadsheet No. 428 (November 28, 1958) "The Development of the Steel Industry", without entering into political controversy regarding ownership and control, the problems involved in planning the development of the industry whatever form of organization is finally adopted. The most important issue regarding the organization of the industry is simply whether one form of organization is better able than another to help the industry to provide the steel that is needed for the growth of the rest of the economy. Decisions will be required from time to time as to the total capacity of the industry and also detailed decisions on the building of individual plants. The former will have to be based on estimates of the growth of industrial production, which in post-war conditions are exceedingly difficult to make. The latter will continue to be influenced by assessments of future prospects for supply and demand, whether the industry is privately owned and controlled, or privately owned but supervised by an official board as at present, or both publicly controlled and publicly owned. Pricing policies will affect both the total demand for all kinds of steel and the demand for particular products. Location will be a matter of controversy because argument will continue that one location is better or worse than another not only on the grounds of productive efficiency, but also on account of the social issues involved in siting such large and vital industrial units. The development of the European Economic Community and the possible association of Britain with it will affect decisions about the capacity and location of the British industry, and particularly the question of the acceptance of some imports as against the objective of self-sufficiency in steel. These are the real economic issues, and questions of ownership and control are significant economically only in so far as they contribute to their solution.

Future of Television in Britain

Some of the factors which should be taken into account when considering the future development of television are set out in a broadsheet, "Prospects for Television" (No. 427, October 31, 1958), issued by Political and Economic Planning. Without seeking to argue that a certain type of development should occur or to suggest who would be best able to undertake it, the broadsheet shows that there are many possibilities and that television in Britain need not be as limited as is sometimes imagined. The four remaining channels in Band 3 could be used to provide another television service for most of the country as soon as the Government decided to make them available (subject to available finance), but this would utilize all available very high-frequency channels and would reinforce the strength of present standards while leaving untackled the problems of higher definition and colour and of ultra high-frequency. It might also prevent the development of colour or higher definition on very high frequency, and would leave no room for parallel transmissions if further services were required. Two programmes could be provided on the remaining very high-frequency channels, each serving nearly two-thirds of the population, while allowing some local low-powered stations of Britain, but national coverage would not be achieved and there could be no further programmes or room for manœuvre. It is unlikely that the present very high-frequency channels or their limited extension will prove adequate for the future, and the main hope seems to lie in the development of the ultra high-frequency bands, which will leave room for a wider entry and allow a higher definition system and colour to be introduced when wanted. It should be possible to have quite a number of national and local television stations if they are wanted, and the proposed extension of the hours of television would permit the provision of a wider range of programmes for differing tastes but would add considerably to costs.

Nuclear Power Station on the Lleyn Peninsula

Intense opposition to the building of the nuclear power station at Edern in the Lleyn Peninsula is strongly brought out in the annual report of the Caernarvonshire Branch of the Society for the Preservation of Rural Wales. To protect the beauty and tranquillity of this rare and unspoilt coast, the National Parks Commission declared it an "area of outstanding natural beauty" on September 13, 1956; this was confirmed by the Minister of Fuel and

Power on May 27, 1957. Opposition to the new station is based not only on the despoliation of natural beauty but also because "the influx of workmen from outside, the rapidly changing levels of employment and its insecure basis, will upset agriculture and other stable industries by the uneven pattern of employment and create great disturbance". The Society's arguments have been set out in a specially prepared booklet, which can be obtained from W. Twiston Davies, Plas Hebog, Beddgelert, North Wales.

Curator

ALTHOUGH the museum profession is now attracting to its ranks more people than ever before, there are very few publications devoted to museology. For this reason alone the appearance of the quarterly periodical, *Curator* (1, No. 1, January 1958. Pp. 96. Annual subscription: 5 dollars), issued by the American Museum of Natural History, New York, is a welcome addition to the scanty literature. The days when a museum curator was a recluse, generally non-academic, are past, and the present-day official is relatively young, a specialist in a cognate subject and fully alive to the new demands of the public. There is thus no need for the editors to apologize for this new journal, and indeed the profession should be grateful to them for the initiative shown. A high standard of production was insisted upon for the first issue and this has been fully maintained throughout the year in the course of which ninety-four articles have been published, all of them of use to the curator who, unlike many of his academic colleagues, has to be proficient in a great variety of directions. *Curator* gives a general account of his activities, summarizes and reduces to print many of the thoughts in the mind of curators to-day and offers much information regarding new materials and techniques.

Maser Observations in Radio Astronomy

IN a paper presented at the one-hundredth meeting of the American Astronomical Society (and reported briefly in *Astron. J.*, 63, 301; 1958), L. E. Alsop, J. A. Giordmaine, C. H. Mayer and C. H. Townes report what is possibly the first attempt to use maser techniques in radio astronomy. The maser amplifier is a three-level Bloembergen type, with a 0·1 per cent concentration of Cr^{3+} in ruby serving as the paramagnetic medium. The ruby crystal is mounted in a double resonant microwave cavity in liquid helium at 1·4° K. and in a magnetic field of 3,500 oersteds. The optimum signal-to-noise ratio for the system is obtained with a gain of about 20 decibels. The maser is used as a pre-amplifier and is mounted near the focal point of the 50-ft. reflector of the U.S. Naval Research Laboratory. The results obtained show an improvement factor of about ten in signal-to-noise ratio over the same installation without the maser pre-amplifier, in accordance with the expected low noise characteristics of maser amplifiers. Observations were made of Venus, Jupiter and the nebula NGC 4486, and they demonstrate the feasibility of applying maser techniques to radio-astronomical observations.

Permanent Graticules

WORK at the Reference Standards Laboratories of the Australian Commonwealth Department of Supply has culminated in the introduction of a new method for the production of graticules, known as the 'interstitial graticule' process. The method employed is of considerable interest, and the product will undoubtedly find a number of applications, particularly in cases where permanence is the prime requisite (*Aust. J. App. Sci.*, 9, 207; 1958). The desired pattern is first produced on the surface of the glass. By a process of electrolysis at an elevated temperature the pattern is transferred in ionic form below the glass surface. Subsequent treatment involving chemical reduction converts the 'ionic' image to metal and the graticule pattern then becomes readily visible and is as stable as the glass itself. By suitable choice of metal and conditions of processing the final pattern may be black or coloured, transparent or opaque. The inventors of the process, A. J. C. Hall and J. C. Hayes, have recently been awarded the Waverley Gold Medal and Prize by the journal *Research* for an essay on their work.

Records of Nodulation in *Coriaria*

IN referring to the root nodules borne by *Coriaria* spp. (*Nature*, 182, 474; 1958), Dr. Bond commented that although their occurrence in New Zealand is known, there seem to be no records in the literature. Mr. R. E. R. Grimmett (formerly superintendent of the Rukuhia Soil Research Station, Hamilton, N.Z.) has directed attention to an article, by him, using the pseudonym "Cryptos" and published in the August 1944 issue of *Forest and Bird*, the journal of the New Zealand Forest and Bird Protection Society. Under the title of "The Much-maligned Tutu"—the latter being the Maori name for *Coriaria* spp.—Mr. Grimmett recorded the regular occurrence of nodules on a species of *Coriaria* (now identified as *C. arborea*) in the Wairarapa district, and testified to the faculty of this and other species of the genus for colonizing raw mineral soils and improving fertility, facilitating the eventual establishment of forest. Like Dr. Bond, Mr. Grimmett referred to the paucity of native legumes in New Zealand and envisaged the possibility that *Coriaria* has been a main native source of biologically fixed nitrogen in that country. The field observations which he cited are in excellent accord with such results of laboratory experiments as are available.

International Grassland Congress

THE eighth International Grassland Congress will be held in Reading during July 11–21, 1960. Reading will prove to be a very appropriate town, since it is within easy reach of several important centres of agricultural research. Pre-Congress tours of grassland areas and research institutes are being planned. The main problems to be discussed are: pasture management and fertilizing; plant breeding and genetics; conservation—recent developments; problems of tropical grassland; estimation of grazing intake; biochemistry of pasture plants; hormone stimulation of grazing animals; special statistical techniques. The organizing committee is commissioning the majority of papers to be presented to the Congress, but it will also consider requests from research workers who wish to present papers of particular interest. Further information can be obtained from the Secretary, Eighth International Grassland Congress, Reading, Berks.

Symposium on Interferometry

AN international symposium on interferometry is to be held at the National Physical Laboratory, Teddington, Middlesex, during June 9–11. The symposium is intended for specialists and will not deal

primarily with technical applications. There will be four half-day sessions devoted to the presentation of papers and to discussion, and a fifth session for demonstrations. About twenty main papers have been invited and will be printed and circulated in advance. Additional short contributions will be welcomed in the form of contributions to the discussion on the main papers, or in the form of demonstrations. The main papers, the discussions, and notes on the demonstrations will be collected and published after the symposium in one volume. Attendance is by invitation; applications should be made to Mr. L. H. McDermott at the National Physical Laboratory.

University News: California Institute of Technology

A GRANT of 73,594 dollars from the U.S. National Foundation (formerly the National Foundation for Infantile Paralysis) has been made to Dr. Renato Dulbecco who, with Dr. Marguerite Vogt, is investigating virus inheritance in experiments involving polio virus mutations. Another grant, of 33,943 dollars, has been made by the National Foundation to Prof. Linus Pauling, for investigations on the structure of nucleic acids.

Nottingham

THE University of Nottingham has received an offer of £100,000 from Rolls-Royce, Ltd., to endow a chair of thermodynamics in the Faculty of Applied Science. This chair is to be established by the Company in recognition of Lord Hives's contribution to engineering science, and will be known as the Hives chair of thermodynamics. It is hoped to encourage the training of an increased number of technologists and the development of a strong research school in thermodynamics. The University plans to increase its output of mechanical engineers by 250 per cent in 1965, and new laboratories to make this possible are under construction. One of these new laboratories will accommodate thermodynamics, fluid mechanics and heat transfer and occupies some 30,000 sq. ft. The new professor will be responsible for these laboratories and the development of researches in these fields.

Announcements

THE Council of the Institution of Mechanical Engineers has awarded the 1959 James Watt International Medal to (the late) Sir Claude Gibb as an engineer who achieved international recognition both by his work as a mechanical engineer and by the ability with which he applied science to the progress of mechanical engineering.

DR. MAX A. LAUFFER, professor of biophysics and dean of the Division of Natural Sciences in the University of Pittsburgh, has been awarded the 1958 Pittsburgh Award of the Pittsburgh Section of the American Chemical Society. Recently his main researches have been on the hydration of viruses and proteins, and the relationship between their physical, chemical and biological properties.

Mr. A. BARCLAY, keeper of the Department of Chemistry, and Mr. E. W. White, deputy keeper in the Department of Aeronautics in the Science Museum, South Kensington, are to retire on March 31. Dr. S. E. Janson, deputy keeper in the Department of Chemistry, has been appointed keeper, in succession to Mr. Barclay and Mr. F. Greenaway and Mr. W. Winton have been appointed deputy keepers from April 1.

A TRANSLATION Service has recently been set up by the Iron and Steel Institute with the collaboration of several large companies and of the British Iron and Steel Research Association. The Service is open to both members and non-members in Great Britain and abroad. Some 530 translations are already available, a large proportion of them from German or Russian, and a classified list of the translations made in the first year is now available; it is kept up-to-date by fortnightly lists (with classified cumulations every six weeks). Inquiries should be addressed to the British Iron and Steel Industry Translation Service, Iron and Steel Institute, 4 Grosvenor Gardens, London, S.W.1.

A course for senior technical executives in industry is being held at the Harwell Reactor School during June 15–25, the fee being 50 guineas. Forms of application and further details can be obtained from the Reactor School, Atomic Energy Research Establishment, Harwell, near Didcot.

A SYMPOSIUM on Boundary Problems in Differential Equations, with especial reference to recent developments in this field, will be held by the Mathematics Research Center, United States Army, at the University of Wisconsin during April 20–22. Further information can be obtained from R. E. Langer, Director, Mathematics Research Center, U.S. Army, 1118 West Johnson Street, Madison 6, Wisconsin.

A CONFERENCE on Electrically Exploded Wires, sponsored by the Thermal Radiation Laboratory of the Geophysics Research Directorate of the U.S. Air Force Cambridge Research Center, will be held at the Somerset Hotel, Boston, Massachusetts, during April 2–3. Invited and contributed papers on both theory and uses of exploding wires will be presented. Further information can be obtained from W. C. Chace, Thermal Radiation Laboratory, CRZCM, Geophysics Research Directorate, Air Force Cambridge Research Center, Bedford, Massachusetts.

THE English Electric Valve Co., Ltd., is holding an exhibition at the Kensington Palace Hotel, London, during March 17–21. The display will be devoted to modern valve design technique in the fields of radar, communication, transmitting, broadcasting—both sound and vision—and instrumentation, together with new types of storage tubes. Further information can be obtained from A. J. Thoroughgood, English Electric Valve Co., Ltd., Waterhouse Lane, Chelmsford, Essex.

A SPECIAL short course in Stereospecific Polymers and Block and Graft Co-polymers is being held in the Department of Chemical Technology of the Bradford Institute of Technology on February 27 and 28. Prof. C. E. H. Bawn will lecture on the preparation of stereospecific polymers; Dr. I. Goodman on stereochemical structure and polymer properties; Dr. C. H. Bamford on the preparation of block and graft co-polymers; and Dr. W. Cooper on the properties and uses of block and graft co-polymers. The fee for the course is 45*s*. Application forms can be obtained from the Registrar, Institute of Technology, Bradford.

ERRATUM. In the communication entitled "Penicillin Derivatives of *p*-Aminobenzyl Penicillin" in *Nature* of January 17, p. 180, the units throughout should be "u./ml.", not "μ/ml." as printed.

MECHANIZATION OF THOUGHT PROCESSES

A SYMPOSIUM entitled "The Mechanization of Thought Processes" was held at the National Physical Laboratory during November 24–27. About two hundred invited delegates came from thirteen different countries to listen to, and discuss, papers on a wide range of topics related to 'artificial intelligence'. Associated with the symposium was an exhibition of devices and machines related to the general theme.

Dr. M. L. Minsky, of the Massachusetts Institute of Technology, gave the opening paper, which was concerned with "Heuristic Programming". Heuristic methods can be distinguished from the straightforward methods of solving a problem by the fact that they cannot be guaranteed to work. They are not 'algorithms'. The paper dealt with programmes for computers rather than with special machines, because any machine that can be fully specified can certainly be simulated on a digital computer, and trials by computer are less expensive.

The special features of heuristic methods discussed were 'pattern recognition', 'learning', 'planning ahead' and the use of analogies or models. These features were illustrated by a proposed programme for proving theorems in Euclidean geometry, where the model consists of actual constructions of points and lines. When tried out on the theorem that 'the base angles of an isosceles triangle are equal', it provided an unusual proof, using the congruence of the triangle to its mirror image.

There were two other papers on the general principles of intelligent machines, by Dr. D. M. MacKay, of King's College, London, and Dr. J. McCarthy, of the Massachusetts Institute of Technology. Dr. MacKay's paper examined the problems of obtaining intelligence in machines, and of evaluating it and distinguishing it from mere ability to calculate. He was led to the conclusion that one needed a hybrid system consisting of a digital decision process with an analogue process for evaluating 'weight' of information and proximity of a solution, etc. Several of the later papers concerned such devices.

Dr. McCarthy described a computer programme which he is developing, called the 'advice taker'. This programme, when given a set of statements about the world, is intended to deduce conclusions about action to be taken. In the discussion, some speakers felt that the proposed 'machine' would be too logical, and that practical decisions are not made in this way. It was agreed that the final answer would be given when the programme could be shown to work, or not, as the case may be.

It is not possible to describe here all the papers that were read and discussed. They can perhaps be divided into four groups, and some from each group will be mentioned. The groups are: (1) proposed mechanisms for intelligent machines, not necessarily related to neural mechanisms; (2) proposed mechanisms for intelligent machines which bear some relation to what is known of neural mechanisms; (3) the lessons to be learnt from the study of perception; (4) a number of related topics and applications.

Perhaps the most interesting mechanisms discussed at the symposium were those that attempted to reproduce some of the known constructional features of the brain. They were contained in papers by Dr. A. M. Uttley, of the National Physical Laboratory, Dr. F. Rosenblatt, of Cornell Aeronautical Laboratories, and Dr. W. S. McCulloch, of the Massachusetts Institute of Technology.

Dr. A. M. Uttley's 'conditional probability computer' embodies a classifying network, or 'tree', and a set of counters to record the number of instances of each possible state of the input channels. These counts are recorded in a logarithmic scale, so that their differences represent the logarithms of estimated conditional probabilities. The conditional probabilities are used to infer patterns at the input when only part of the pattern has actually been presented to the machine. In the paper presented to the symposium, this work was developed by considering how neural networks, with their connexions in some respects random, could perform in a way similar to the highly organized electronic model.

Dr. F. Rosenblatt described recent theoretical work on the behaviour of the 'perceptron'. This is a 'neural' network in which a large population of 'neurons' have random connexions to the inputs, and their connexions to the outputs are paralleled by feed-back connexions which modify the parameters of the 'neuron' so that frequent stimulation of an output will reinforce the neurons which feed this output. The hypothetical neurons assumed by Rosenblatt obey linear equations, for convenience; but computer simulation has shown that they would work with a wide range of characteristics.

Dr. W. S. McCulloch's paper was concerned with hypothetical neurons working with binary signals, and with a threshold—the well-known 'Pitts and McCulloch' neurons. It did not attempt to describe what happens in the brain, but explored switching circuit design using these particular switching elements. The problem considered was how to make switching circuits which are insensitive to variations of threshold.

Dr. O. G. Selfridge, of the Massachusetts Institute of Technology, described a process which was not related to neural mechanisms, but which would adapt and improve itself to handle recognition problems. The process, called a 'pandemonium', was described in rather anthropomorphic terms, but this was perhaps less obscure than an abstract description would have been. The pandemonium contains an assortment of 'demons' each responsible for looking out for a particular feature in the input. Some demons may look for features in the output of lower demons. At the highest level in the system, the strongest output of any demon is detected by a decision demon. Processes were described for inventing demons, making them more or less powerful according to experience, and so forth. A practical example is under development; this is a pandemonium for the translation of manually keyed morse.

A very interesting paper by Dr. Ross Ashby, of Barnwood House Hospital, Gloucester, showed that habituation can be demonstrated in a mechanism without any detailed assumptions about its construction. The only assumptions made were of a behavioural kind. By habituation is meant the decrease of response to a stimulus when it is regularly repeated. An indication was given of the circumstances in which extraneous disturbances could cause de-habituation.

Among the several papers giving the point of view of biologists was one by Dr. H. B. Barlow, of the

University of Cambridge, which treated the coding of signals in sensory mechanisms. There is evidence of mechanisms operating at low levels in sensory pathways to reduce the amount of redundancy in the vast number of parallel information channels. Unlike the recoding proposed by Shannon for communication channels, the aim is not to remove all redundancy, but to reduce the number of pulses on any given channel, and to reduce correlation between channels. For two binary channels, the specification of such a coding device is very simple, and a model of this device was shown in the exhibition.

Among the specialized topics discussed was automatic programming, to which a morning's session was devoted. Dr. Grace Hopper, of Remington Rand, Ltd., gave the opening paper, and the session was rounded off by a paper from Dr. A. P. Ershov, of the Academy of Sciences of the U.S.S.R.

An afternoon's session was devoted to mechanical language translation, and Dr. Ershov, at short notice, said something about the groups working on this subject in the U.S.S.R.

Unusual fields for mechanization formed the subject of several papers. Dr. L. Mehl, of the École Nationale d'Administration, Paris, spoke on automation in the legal world. He described a machine for retrieving legal information and a machine for legal argument. The limitations of such machines are that they are incapable of evaluating data, or of developing the principle of law, so they cannot be a substitute for the jurist.

Dr. F. Paycha, of Paris, spoke about the logical structure of medical diagnosis, emphasizing the vast volume of facts on which it is based, and the need for mechanization to reduce the chance of an error. In the discussion which followed, the question was raised of how far probability considerations should be allowed to influence diagnosis.

Speech recognition was the subject of two papers. Prof. D. B. Fry and Mr. P. Denes, both of University College, London, described how linguistic information has been brought into the problem of speech recognition. A machine capable of handling 13 English phonemes and using digram frequencies to make a decision was shown in the exhibition. A paper by Mr. P. Ladefoged, of the University of Edinburgh, reviewed the whole field of speech perception, making the particular point that speech is not, in any sense, a sequence of small discrete elements.

In the analogous field of visual pattern recognition, a paper was read by Dr. W. K. Taylor, of University College, London.

Other papers dealt with literature searching, the mechanization of administration, and learning in animals, in addition to the subjects mentioned above.

The general impression given by the symposium was that in none of the fields of study is there any finality as to the basic approach to the problem. In the field of intelligent machines, there was a wealth of suggestions, but none of these has yet reached the stage of a successful test. It was also evident that many suggestions that can be made for machines to solve problems or perceive patterns may fail because the number of individual units in the machine is too large and that any practical machine must include some trick to achieve economy of equipment.

The modern theory of automata began with A. M. Turing's proof that universal computing machines were possible. Dr. Turing's ideas, and those of J. von Neumann, led to the construction of electronic computers, which are the working tools of the experimental approach to artificial intelligence. It seems possible that a further great advance in the development of intelligent machines will soon be made.

The *Proceedings* of the symposium, including the papers read, together with the discussion, will be published by H.M. Stationery Office in due course.

D. W. Davies

DEVELOPMENT OF ELECTRIC CABLES

Mr. S. E. Goodall delivered his presidential address before the Institution of Electrical Engineers on October 9. His subject was electric cables, and a substantial part of his address was devoted to reviewing the history of their development.

It was in the year 1812 that the first experiments were made in applying a soluble material, said to be india rubber, to the insulation of copper wires. The great initial development of the electric telegraph took place as a means of inland communication and the circuits employed were almost wholly composed of overhead, open-wire, lines. It was the timely discovery of the excellent properties of gutta percha as an insulant and its practical application to electric cables by Werner Siemens that initiated the development of submarine telegraph cables and indeed of cables generally. The year 1851 saw the first cross-Channel cable in operation, and fifteen years later the first successful telegraph cable spanned the Atlantic Ocean. The pioneer of the electric power cable was Sebastian de Ferranti. The transmission of power by alternating current at 10,000 volts from the Central Station at Deptford to the West End of London was effected by concentric cables of entirely novel design. Oil-impregnated paper was the dielectric, and the type of construction devised by Ferranti remained the basis of high-voltage power cable design for half a century. By 1900 single-core and three-core impregnated paper lead-sheathed cables were in regular manufacture in Britain.

The manufacture of telephone cables developed rapidly from about 1890. Multi-circuit lead-covered cables when first introduced were filled with insulating material such as paraffin wax, but their electrical characteristics were soon greatly improved by the adoption of the dry-core technique, in which advantage is taken of the air interstices to obtain lower electrostatic capacitance. The first cables used for long-distance telephony were simply adaptations of telegraph cables and used gutta percha as a dielectric. For gutta percha, balata was later substituted and this held the field for submarine purposes until comparatively recently.

Two very important developments in high-voltage power cables occurred during the 1920's. The major factor tending to initiate breakdown in high-voltage cables had been traced to ionization in voids

in the dielectric, and the formation of voids had been demonstrated to be associated with the thermal expansion and contraction of cables under varying conditions of load. Improved design and better techniques of impregnation proved to be insufficient to remove the inherent electrical weakness resulting from heating cycles. The first effective remedy was devised by Emanueli, who, in 1920, employed a thin mineral oil as a liquid impregnant applied under pressure from reservoirs at predetermined points in the cable system. An alternative method of suppressing ionization in voids, invented at about the same time, was the use of an inert gas at high pressure. This development did not proceed very rapidly and was seriously interrupted by the Second World War. There are, however, now many important installations of super-tension gas pressure cables.

The distribution of electricity in buildings was first effected by wires insulated with paraffined cotton, but it was not long before rubber was adopted as the insulant. Some indication of the early rate of development of the distribution of electricity to domestic and industrial premises is given by the fact that in 1882 the Society of Telegraph Engineers and Electricians issued their first "Rules and Regulations for the Prevention of Fire Risks from Electric Lighting".

Although the techniques of cable manufacture were being steadily developed and improved, there had been, up to the outbreak of the Second World War, little change in the basic materials and processes. During the Second World War and since, very far-reaching changes have taken place. Plastics and synthetic rubbers have been introduced, some of these materials having excellent electrical characteristics together with satisfactory mechanical properties, and a substantial proportion of the electric cables now manufactured employ these new insulants. It was the development of radar during the Second World War that evoked the urgent demand for cables which would transmit satisfactorily very high-frequency currents, and polythene was the material which enabled this demand to be met. The drastic reduction in the available supplies of natural rubber which developed as the War progressed was the incentive in the search for synthetic substitutes. Polyvinyl chloride, commonly known as P.V.C., is a war-time product which is now firmly established in cable-making practice.

In addition to the introduction of new insulating materials there have been, since the end of the War, important developments in manufacturing methods. As an example of this may be cited the new method of coating wires known as continuous vulcanization. A well-established method of applying the rubber covering to wires involves the continuous interleaving of a group of wires moving longitudinally in parallel between two thin ribbons of rubber. The passage of this layered ribbon between suitably grooved rollers produces individual insulated wires with, of course, seamed coverings. The modern alternative to this is known as continuous vulcanization.

In this process rubber compound is forced on to the wire as a seamless cylindrical coating in the extruding 'head' of a rotary-screw extrusion machine through which the wire is passing at fairly high speed. Immediately on leaving the head the covered wire is passed into a long well-lagged steel tube which contains high-pressure steam, and in this vulcanization takes place. In this process the finished core is produced to very close tolerances by the extensive utilization of electronic methods of automatic control.

Direct extrusion methods are employed for the covering of cables insulated with polyvinyl chloride and polythene. It is not practicable to use, for these synthetic materials, the same machines as are used for natural rubber coatings, but plants designed for polyvinyl chloride can with relatively slight modification be utilized for polythene.

Some important advantages, other than those of improved electrical characteristics, are associated with the use of the new plastics, but there are also limitations.

Polyvinyl chloride has good mechanical properties and, in addition, is strongly resistant to corrosion. For this reason it is used as an external, serving to protect from the corrosive effects of soil waters or of acids such as those produced when textile servings rot through bacterial attack. Wire insulated with polyvinyl chloride or polythene, however, is not capable of withstanding as great an electrical overload as can be tolerated by conductors insulated with vulcanized indiarubber. Ordinary grades of polythene melt at a temperature slightly above 105° C. Polyvinyl chloride, while it has no sharp melting point, becomes softer as the temperature increases and may suffer severe deformation under mechanical stress. The thermal characteristics of polythene can be considerably improved by exposing the material to neutron or electron bombardment. Such treatment effects cross-linkage between the molecular chains in its structure. This eliminates the sharp melting-point and the material becomes rubber-like at about 150° C. Irradiation is, however, expensive, and it appears unlikely that irradiated polythene will be available except for special applications.

Another important synthetic material is silicone-rubber. This material will operate indefinitely at 150° C. and flexibility is retained down to − 70° C. Its electrical properties are similar to those of natural rubber. Cables insulated with silicone-rubber have the unique property that, if exposed to fire, the residue of the insulation is largely pure silica, and after a fire such cables can be operated temporarily provided they are not disturbed.

Mr. Goodall's address ended with a brief review of the technical possibilities and objectives of cable making in Great Britain. The trend towards greater use of plastic materials would, he thought, undoubtedly continue, and there would probably be continued effort towards such reductions of dimensions as might be rendered possible by improved process control methods.

To be able to face intensifying competition from abroad both in the home and export markets, the industry must be prepared to face the consequences of rationalization of production, with consequent regrouping of manufacture and co-operation in one form or another among the different companies concerned. Cable users, on the other hand, must be prepared, in their own and in the national interest, to accept some measure of restriction of choice. The two bugbears of cable making are alternatives and variety, and the industry as a whole possesses surplus plant for many operations, although few if any of these operations are wholly obsolete. In effect, standardization must be directed towards the elimination of unnecessary complication rather than the inclusion of all the variants for which there might be a demand.

JAMES GREIG

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION, AUSTRALIA

CHEMICAL RESEARCH LABORATORIES

THE Commonwealth Scientific and Industrial Research Organization (Australia) has changed the status of one of its largest research groups, the Division of Industrial Chemistry, which has its headquarters at Fishermen's Bend, Melbourne. The Division will in future be known as the C.S.I.R.O. Chemical Research Laboratories, and its chief, Dr. I. W. Wark, becomes the first director of the Laboratories. Two of the largest Sections of the Laboratories will become Divisions (the name used for the major units of C.S.I.R.O.'s activities). Dr. A. L. G. Rees will become chief of the new Division of Chemical Physics and Dr. K. L. Sutherland will become chief of the new Division of Physical Chemistry.

These two new Divisions together with the remaining four major Sections will comprise the Chemical Research Laboratories. These sections and their officers-in-charge are as follows: Minerals Utilization (Mr. R. G. Thomas); Organic Chemistry (Dr. H. H. Hatt); Cement and Ceramics (Mr. A. J. Gaskin); Chemical Engineering (Dr. H. R. C. Pratt). The Foundry Sands Section will continue to be affiliated with the group.

Dr. Wark has been chief of the C.S.I.R.O. Division of Industrial Chemistry since its formation in 1940. Under his guidance this group has grown until it now has a research staff of one hundred and a total staff of three hundred.

More than a third of the research staff has been recruited from overseas, and about half of the Australians have studied abroad for higher degrees.

An adventurous outlook on research within the Chemical Research Laboratories has produced outstanding contributions in many phases of chemical discovery, both in basic science and in the solution of practical problems.

Some of C.S.I.R.O.'s more spectacular applications of science have come from the Chemical Research Laboratories. These include the process using cetyl alcohol for controlling evaporation from dams and reservoirs; the process for separating hafnium from zirconium which is of significance for atomic-powered submarines; and a process for recovering uranium from its ores.

Dr. Wark's own personal research was concerned with the theory of the flotation process for separating minerals from ores, which is of major importance to the mining industry. His pioneering work as a physical chemist in this field gained for him a world-wide reputation, and his book, "Principles of Flotation", first published in 1938, became recognized as a classic on the subject. He is a Fellow of the Australian Academy of Science. For many years he has taken a prominent part in the affairs of the Royal Australian Chemical Institute and has done much to gain a wider appreciation of the importance of chemistry and of science generally. He served as president of the Institute during the year 1957–58.

Dr. A. L. G. Rees, chief of the new Division of Chemical Physics, began his scientific career with a brief temporary lectureship in the University of Western Australia; then he became Beit Fellow at the Imperial College of Science and Technology, London. In 1941 he was awarded the Ph.D. of the University of London and joined the Philips organization in England as head of the Fundamental Research Group. He held this post until 1944, when he was appointed to C.S.I.R.O. to form the Chemical Physics Section. He has undertaken research into the structure and properties of materials. He is the author of many scientific papers on spectroscopy, electron diffraction, electron microscopy, luminescence and allied subjects. He is the author of a book—"Chemistry of the Defect Solid State" (Methuen, London, 1954). He is a Fellow of the Australian Academy of Science and of the Royal Australian Chemical Institute. He received the Institute's Rennie Memorial Medal in 1945 and its H. G. Smith Memorial Medal in 1951.

Dr. K. L. Sutherland, chief of the new Division of Physical Chemistry, began his research career on the froth flotation of minerals, which was supported by a group of mining companies, in the University of Melbourne. He joined C.S.I.R.O. in 1940 and continued his work on flotation, concentrating particularly on the kinetics of the process. He has gained world-wide recognition for his work in this field. In 1947 he was awarded the Davy Faraday Fellowship of the Royal Institution and worked in London for a period. Later, he was awarded the degrees of D.Sc. of the University of Melbourne and Ph.D. of the University of London. He returned to the Division of Industrial Chemistry in 1950. He recently collaborated with Dr. I. W. Wark in the revision of the second edition of Dr. Wark's book, "Principles of Flotation". He is a Fellow of the Royal Australian Chemical Institute. He received the Institute's Rennie Memorial Medal in 1943 and its H. G. Smith Memorial Medal in 1957. The University of Melbourne awarded him the Grimwade Prize in 1943 and the Syme Prize in 1948.

RURAL RESEARCH

THE lack of agricultural development in the comparatively well-watered section of tropical Australia has long presented an enigma. The region has been either hailed as a land of unlimited potentialities or written off as virtually worthless.

It is only in the post-war period that a systematic effort has been made to define the agricultural and pastoral potentialities of the land and solve the problems limiting its exploitation. Officers of the Division of Land Research and Regional Survey of the Commonwealth Scientific and Industrial Research Organization have been in the forefront of this effort and have shown already that large areas of Northern Australia are capable of agricultural

development. By a series of broad-scale land-use potentiality surveys they classified and defined the land. Then Research Stations were established at two type locations to study crop and pasture production. The first of these was for dryland agriculture at Katherine, about two hundred miles south of Darwin, and the second was a joint irrigation venture with the Western Australian Department of Agriculture on the Ord River in the East Kimberleys.

Accounts are given in "Rural Research in C.S.I.R.O." of the successful outcome of research at these stations over the past decade (25, September 1958). Reasons for past failures have been explained, and, with the new knowledge, crops such as sugar, rice, cotton and peanuts have been cultivated successfully under experimental conditions. Returns from peanuts as a major cash crop at Katherine and successes with subsidiary crops offer promise for the establishment of profitable mixed farming with associated livestock industries over large areas. At the Kimberley Research Station, sugar has done extremely well under irrigation, while rice, cotton and safflower are very promising. These experimental results must be supplemented by further economic data from farm-scale trials before settlement can be planned.

This information is now being sought as part of a joint venture with the Western Australian Department of Agriculture.

PARAPSYCHOLOGY

THE Institute for the Study of Mental Images was started informally in May 1956 as a private venture "in order to evaluate the status and behaviour of mental images not immediately related to sensory stimuli, and to pursue theoretical investigations in general psychophysical theory". An investigation of hypnagogic images is claimed to be in progress, assisted by a grant from the Parapsychology Foundation, New York. Three communications have now been published*.

In fairness to the authors, it must be made clear at once that their tripartite paper is a serious and learned essay in the philosophy of science—or in scientific philosophy, as it might better be termed in this case. Of its type, it is good. The technicalities are mainly in the language of physics, which most scientific readers will find more to their taste than symbolic logic; the text, though it could be clearer, compares well with that of the majority of disquisitions of this type; and the authors have avoided the more obvious traps. On the other hand, they have had to pay the price of extreme generality, abstraction and impartiality by seeming a little inconclusive.

But let them speak for themselves. The paper attempts "to bridge the considerable gap between psychiatry and advanced physics as the first step towards a psycho-physical theory of the world. A beginning is made by following Sir Arthur Eddington in questioning the usual *separability assumptions* which underlie all scientific investigations". (By "psychiatry" they clearly mean a class of psychological theory, not the day-to-day practice of the art.) Their purpose is "to outline a psycho-physical world theory which is both self-consistent and of sufficient generality to provide a framework for the discussion of all widely held opinions. . . . If this ideal could be realized, men might indeed become as little children, and continue throughout their lives to learn by experience, and to realize their mistakes, without becoming involved in paranoid ideological systems—whether religious, scientific, political or psychoanalytic".

They add, modestly enough, that their theory "has two of the chief characteristics of all paranoid phantasy, i.e., that it is self-consistent and incomplete".

The particular "widely-held opinions" exemplified are, of course, those related to the credibility (in the ordinary sense) of parapsychological phenomena and 'miracles' in general. The central point appears to be that it is illogical to claim that an alleged paranormal phenomenon is impossible by appealing to a scientific argument which rests on an assumption that absolutely precludes the phenomenon; one might as well say simply: "I do not believe it because it contradicts what I *do* believe". The psychiatrist, Dr. Michael Balint, is taken to task for falling into this elementary trap in connexion with the Lourdes 'miracles'. He is quoted as saying, in effect, that the criteria of cure (for example, that it must be instantaneous) are so unrealistic as to force the doctors concerned to distort the facts. It is true that Dr. Balint is out of his depth in these logical waters, or he would have realized that all arbitrary criteria (including that graven image, 'statistical significance') distort facts; but he is a practising clinician, and was clearly, though perhaps unwittingly, giving a clinical opinion rather than a sample of pure reason.

The authors of this paper, on the other hand, instead of taking sides, have attempted to found a system of thought in which it will not be necessary to take sides; in which what we now have to call either supernatural or bogus will be seen as natural. This ambitious project may be attempted in innumerable ways, varying from the easy to the impossible. The easiest way is simply to assert that all things are possible. The respectable empiricist who insists that no duly authenticated observation should be rejected on theoretical grounds evades being charged with this unlimited credulity at the risk of being challenged on his standard of due authentication. It is a weakness of this paper that it does not adequately meet the challenge.

So far as the authors' discursive style reveals, their basic strategy is to invoke the well-known common cause type of theory. Thus, if the universe is a gigantic statistical family tree, significant correlations of some kind should crop up occasionally in card-guessing experiments and the like. The interest lies, not in the general proposition as such, but in how it is handled; here the authors' many well-informed and thought-provoking remarks are marred by a disappointing reluctance to come to the point. W. E. HICK

* "Introduction to Parapsychology". By C. C. L. Gregory and Anita Kohsen. Communications of the Institute for the Study of Mental Images. Vol. 1, Part 1 (1957); Parts 2 and 3 (1958). (Church Crookham, Hants: Institute for the Study of Mental Images.) 3s. each.

GEOLOGY AND PALÆONTOLOGY IN MALAYA

Pre-Tertiary Stratigraphic Succession in Malaya

As a result of progress in geological mapping in Malaya since 1939 it has been possible to clarify and to extend considerably the range of known pre-Tertiary stratigraphic units. Formerly, for lack of sufficient palæontological evidence, the sedimentary formations in Malaya were believed by Scrivenor[1,2] and Willbourn[1] to be limited within the late Palæozoic and early Mesozoic eras to the range Carboniferous–Permian–Triassic, and it was thought that, except in the extreme north-western part of the country where arenaceous rocks had been found to underlie calcareous rocks, the formations older than the granite consisted only of one major sequence of characteristically arenaceous rocks of Triassic age and one major sequence of characteristically calcareous rocks of Carboniferous–Permian age. Although some anomalies were observed they were explained by folding, possible unconformity, or the paucity of fossil species, which are too scanty for precise age determinations.

The fact that fossils were so rare in the stratified rocks made it necessary to use lithological characteristics for mapping over large areas. Certain inconsistencies were examined in greater detail by subsequent workers, including Richardson[3], who in 1939 noted in western Pahang that characteristically arenaceous rocks lay structurally immediately beneath characteristically calcareous rocks of Carboniferous–Permian age; and Fitch[4], who in 1940 noted in eastern Pahang that characteristically argillaceous with some calcareous rocks of Lower Carboniferous age lay structurally immediately beneath unfossiliferous arenaceous rocks of presumed Triassic age. Richardson, Service, and Alexander[5] in 1941 recorded their independent beliefs that in western Pahang the unfossiliferous arenaceous rocks which lay structurally immediately beneath the 'Calcareous Series' of Carboniferous–Permian age should not be regarded as Triassic, even though no fossils had been found to prove otherwise. The evidence then available was summarized[6,7] and subsequent work by Alexander[8] between 1947 and 1951 showed that the characteristics of the ultra-stable heavy mineral assemblages of this unfossiliferous arenaceous sequence of western Pahang were not correlative with those of the fossiliferous Triassic rocks found farther east in central Pahang, and added force to the view that this arenaceous sequence is indeed not younger than Carboniferous in age. The status of the proved stratigraphical succession in Malaya by 1951 was then as compiled in 1954 and published in the "International Stratigraphic Lexicon"[9].

In 1952, the Kelantan (Trengganu) Pahang States border area was allocated for systematic detailed mapping. Later, after studying the geological map of Thailand[10], noting certain trans-border anomalies, and doing some preliminary photogeological work, I prepared the ground during November 1954 at the Bangkok meetings of the Economic Commission for Asia and the Far East Working Party of Senior Geologists for the Geological Map of South-East Asia for a detailed stratigraphic correlation survey in the Malaya–Thailand international border areas. Early in 1955 certain parts of Perlis and Kedah were allocated for systematic detailed geological mapping as part of a co-ordinated programme of re-examination of several inconclusive stratigraphic horizons in Malaya, and in 1955–56 the stratigraphic correlation survey in the international border areas[11] was undertaken by a joint party of geologists from Malaya and Thailand.

The results of the work both in the Langkawi Islands and Perlis, and in Trengganu and Kelantan, have been most gratifying and have shown that the

Table 1. Pre-Tertiary Stratigraphic Successions in Malaya and Thailand

Malaya	Age	Thailand
Not yet proved	Late Cretaceous	Not yet proved
Gagau Formation: a predominantly arenaceous sequence not previously differentiated	Early Cretaceous / Late Jurassic	Not differentiated
Not yet proved	Early Jurassic	
Lipis Group: a characteristically argillo–arenaceous sequence, formerly known as the 'Younger Arenaceous Series', including an argillo–calcareous formation of late Triassic age; on the West Coast the group is represented by the Semanggol Formation of middle Triassic Age	Triassic	Khorat Series, including the Kamawkala Limestone of late Triassic age
Raub Group: a characteristically calcareous sequence formerly known as the 'Calcareous Series' (the old 'Raub Series')	Permian / Late Carboniferous	Rat Buri Limestone
Bentong Group: a characteristically arenaceous sequence formerly known as the 'Older Arenaceous Series', including lenticular cherty formations towards the base of the succession	Carboniferous	Kanchanaburi Series
Kuantan Group: a characteristically argillaceous sequence, not previously named, including lenticular masses of a calcareous formation high in the succession	Early Carboniferous	
Not yet proved	Devonian	No Devonian proved
Setul Formation: a predominantly calcareous sequence not previously differentiated	Silurian / Ordovician	Thung Song Limestone
Machinchang Formation: a predominantly argillo–arenaceous sequence, formerly known as 'C_2 beds' and mapped as Carboniferous	Late Cambrian	Phuket Series
Not yet proved	Early Cambrian	

stratigraphic succession in Malaya does indeed range from at least as early as late Cambrian to as late as early Cretaceous, with very little interruption except possibly in the Devonian and in the Jurassic. The positive identification of Ordovician/Silurian fossils found during the course of the Malaya–Thailand border survey in the predominantly calcareous sequence of the Langkawi Islands[12], together with the evidence of structural alignment of the underlying arenaceous rocks with those carrying late Cambrian fossils on the Thai island of Terutau, were critical factors in establishing the identity of the older rocks in Malaya. Such positive fossil evidence has not yet been obtained for the predominantly arenaceous beds overlying granite found in the Kelantan (Trengganu) Pahang border areas, but is sufficient to indicate for them late Jurassic or early Cretaceous age. In the current research programme is included a project for determining the ages of the various granite masses by isotope ratios of radioactive elements in constituent minerals such as zircon, and it is hoped that the results obtained will establish some correlation with the sedimentary indications already found.

In view of the considerable extension of the proved time-range of the Malayan sedimentary succession I decided early in 1958 to give to the various rock groups and formations in Malaya definite names according to type localities in accordance with the recommendations of the International Geological Congress Sub-Commission for Stratigraphic Terminology. Table 1 summarizes the newly adopted nomenclature and the comparative classification of Palæozoic and Mesozoic stratigraphic sequences now established between Malaya and Thailand[13].

This communication is written as a preliminary announcement to a more detailed paper now being prepared in order to bring up to date the stratigraphic descriptions appearing in the first edition of the section on Malaya in the International Stratigraphic Lexicon. The information in this and the two following communications is published with the authority of the Minister of Natural Resources of the Federation of Malaya.

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Sept. 30.

[1] Scrivenor, J. B., and Willbourn, E. S., *J. Mal. Branch, Roy. Asiatic Soc.*, **1**, 338 (1923).
[2] Scrivenor, J. B., "Geology of Malaya" (Macmillan, London, 1931).
[3] Richardson, J. A., Geol. Surv. F.M.S. Mem. 3 (Batu Gajah, 1939).
[4] Fitch, F. H., Geol. Surv. F.M.S. Ann. Rep. 1939, 27 (Batu Gajah, 1940); Geol. Surv. M.U. Ann. Rep. 1946, 49 (Batu Gajah, 1947); Geol. Surv. Fed. Mal. Mem. 6 (Batu Gajah, 1951).
[5] Richardson, J. A., Service, H., and Alexander, J. B., Geol. Surv. F.M.S. Ann. Rep. 1940, 14 (Batu Gajah, 1941).
[6] Richardson, J. A., *Geol. Mag.*, **83**, 217 (1946).
[7] Alexander, J. B., Geol. Surv. Fed. Mal. Ann. Rep. 1946, 36 (Batu Gajah, 1947).
[8] Alexander, J. B., Geol. Surv. Fed. Mal. Ann. Rep. 1949, 29 (Batu Gajah, 1950); and unpublished thesis (1951).
[9] Alexander, J. B., "I.C.S. Lexicon", **3**, Asia, fascicules 6*b* and 7*c*, Malaya, 1954 (Centre National de la Recherche Scientifique, Paris, 1956).
[10] Sresthuputra, V., Buravas, S., and Brown, G. F., Geol. Surv. Mem. 1 (Royal Thai Dept. Mines, Bangkok, 1953).
[11] Alexander, J. B., paper presented at E.C.A.F.E. Conf. Sen. Geol. (Calcutta, 1957).
[12] Jones, C. R., paper presented at Pac. Sci. Congress (Bangkok, 1957).
[13] Sethaput, V., "I.C.S. Lexicon", **3**, Asia, fascicule 6*c*, Thailand (1955) (Centre National de la Recherche Scientifique, Paris, 1956).

Jurassic/Cretaceous Sediments in Malaya

A formation of gently dipping sedimentary rocks forming the Gunong Gagau plateau was found during a reconnaissance of the Kelantan (Trengganu) Pahang borders in 1952. The succession consists of a coarse basal conglomerate, with cobbles as much as 10 in. in diameter, overlain by a series of progressively finer, interbedded white pebble beds and orthoquartzites, both the latter composed almost entirely of quartz. There are occasional thin red mudstone horizons in which occur plant remains, most of them fragmentary. Recently, better-preserved specimens have been collected which indicate a late Jurassic or early Cretaceous age for the higher part of the formation.

Both in lithology and in the virtual absence of folding and metamorphism these strata appear to be quite unlike any other group of rocks in Malaya, and are the first sedimentary rocks of an age between Trias and Tertiary to have been found. In part they rest with notable unconformity on vertical or steeply dipping interbedded shales, metaquartzites and conglomerates of probable Carboniferous or Permian age. The latter group are characterized by their dark, mainly black, colour arising from the high argillaceous content of the whole succession, and contrast sharply with the light-coloured, overlying beds. Elsewhere, the basal conglomerate overlies granite.

Their discovery throws interesting light on the tectonic history of Malaya. Previously, the folding of sediments and emplacement of granite were thought to be penecontemporaneous and, by analogy with surrounding countries, probably of late Cretaceous or early Tertiary age. However, the present evidence shows that at least a major part of the folding took place early in Jurassic time.

The field-work during the course of which the discoveries were made forms part of the general research programme of the Geological Survey of the Federation of Malaya, and after examination of the area is complete the results will form the subject of a more comprehensive paper.

This preliminary communication is published by permission of the Director of Geological Survey.

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Sept. 30.

Graptolites recorded from Malaya

Geological investigations within the past few years in the north-western States of the Federation of Malaya have resulted in the discovery in 1956 of graptolites in shale bands interbedded with limestone of Ordovician/Silurian age[1] which outcrop along the north-eastern shore-line sections of the Langkawi Islands (6° 25′ N.; 99° 55′ E.). The group of islands lies in the northern funnel of the Straits of Malacca between 20 and 30 miles west of the State of Perlis. Graptolites have been found since in shale associated with limestone in the northern end of the Kinta Valley (4° 46′ N.; 101° 06′ E.) of central Perak. Although the graptolites which have been recovered so far are generally of poor preservation they provide sufficient information to date several horizons with considerable accuracy within the period Caradocian–

Llandovery. Previously, for lack of sufficient palæontological evidence, these formations had been ascribed to the Carboniferous period by conservative lithological comparison with fossil-bearing strata on the mainland of Malaya[2].

It is of more than passing interest to note that the nearest locality to Malaya previously known to provide a graptolitic fauna of Llandovery genera is that at Panghsa-pye (22° 42′ N.; 97° 16′ E.) in the Northern Shan States of Burma as recorded by Holland[3], Chhibber[4], and Krishnan and Jacob[3]. In addition, graptolite-bearing beds of Valentian age have been reported by Sondhi[5] at Wapya Taung (20° 53′ N.; 96° 38′ E.) and at Kwawktap (20° 05′ N.; 96° 46′ E.) in the Southern Shan States. These occurrences all lie more than a thousand miles north of the Langkawi Islands, so that the localities in the Federation of Malaya provide a link between Burma and Australia which will undoubtedly be of great value to palæogeographers in the future.

The field-work during the course of which the discoveries in Malaya were made forms part of a co-ordinated programme of re-examination of several inconclusive stratigraphic horizons, and I am indebted to the Director of Geological Survey, Federation of Malaya, for his guidance and permission to publish this communication.

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Sept. 30.

[1] Jones, C. R., paper presented at Pac. Sci. Congress (Bangkok, 1957).
[2] Scrivenor, J. B., "The Geology of Malaya" (Macmillan, London, 1931).
[3] Holland, T. H. (1926), Krishnan, M. S., and Jacob, K. (1955), "I.C.S. Lexicon", 3, Asia, fascicules 6*d* and 8*b*, Burma (Centre National de la Recherche Scientifique, Paris, 1956).
[4] Chhibber, H. L., "The Geology of Burma" (Macmillan, London, 1934).
[5] Sondhi, V. P., *Rec. Geol. Surv. Ind.*, **67**, 212 (1933).

A RAPID MICRO-QUANTITATIVE METHOD FOR ESTIMATING SERUM CALCIUM

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An accurate micro-method for estimating serum calcium in children and infants is a necessity in many clinical laboratories. Several micro-methods, using dye solutions, were examined in order to select one for use in this laboratory. The criteria laid down for the method to be adopted were: (1) avoidance of calcium precipitation by oxalate, (2) specificity, (3) accuracy, (4) reproducibility, (5) simplicity, (6) use of available apparatus without any modifications, (7) easily available chemicals, (8) reasonable stability of the reagents as stock solutions. Each of the methods examined had some drawback which precluded its adoption as a routine procedure.

However, the method described by Tammelin and Morgensen[1] satisfied the criteria mentioned earlier. In alkaline solutions murexide–ammonium purpurate is specific for calcium. They made use of the reaction in which the colour of a murexide solution changes from purple to pink on the addition of calcium. Their results showed that it was possible to estimate microgram quantities of calcium in water solutions, even in the presence of magnesium, by means of spectrophotometric determination of the calcium murexide complex. Accordingly, the calcium concentration of 315 samples of serum—obtained from blood donors—was determined to find out the normal range for this method. The purpose of this communication is to present the results obtained and to demonstrate a method for correcting the results to agree with oxalate precipitation methods, as the accepted normal range for serum calcium has been determined by these methods.

The following reagents were used: (1) saturated murexide solution is prepared with distilled water and the solution stored, in a brown bottle, in the ± 4° C. refrigerator to decrease the rate of decomposition. A fresh solution need only be prepared after 3–4 weeks. A sufficient volume for the number of tests is centrifuged before use. (2) Piperidine. (3) Stock standard calcium (1 mgm. ≡ 1 ml.). 'Analar' grade of calcium carbonate is dried at 105° C. for 24 hr. 2·5 gm. are weighed and transferred to a 1-l. flask. 200 ml. of distilled water and 50 ml. of normal hydrochloric acid are added. When dissolved, water is added to the mark. (4) Working standard calcium (9 mgm. per 100 ml.) prepared from the stock solution. The apparatus used were a 'Unicam' *S.P.* 600 spectrophotometer and auto self-set zero micropipettes.

Three test tubes are labelled *T* (test serum), *S* (standard calcium solution) and *B* (blank). 4·9 ml. of distilled water is added to tubes *T* and *S* and 5 ml. to tube *B*. 0·1 ml. of the test serum is pipetted into *T* and 0·1 ml. of the working standard calcium solution into *S*. Then one drop of piperidine and 0·25 ml. of the saturated murexide solution (centrifuged before use) are added to each of the three tubes and the contents mixed thoroughly. The optical densities of the three solutions are then read in the spectrophotometer at 500 mμ wave-length using the 0·5-cm. cuvettes, the instrument being set at zero with a water blank.

A permanent standard calibration curve is not possible because, on storage, there is a decrease in the optical density of the saturated murexide solution.

By calculation:

$$\text{Serum calcium} = \frac{\text{Reading of (Test Serum–Blank)}}{\text{Reading of (Ca Std.–Blank)}} \times 9 \text{ mgm./100 ml.}$$

Freeze-dried serum, analysed by the Joint Committee of the Association of Clinical Pathologists and the Association of Clinical Biochemists, was obtained from C. David Keeler, Ltd., and reconstituted. The method was carried out on this serum. The corrected calcium concentration of the

Table 1. SERUM CALCIUM RANGE (MGM. PER 100 ML.)

Author	Method	Lower 1 per cent	Lower 10 per cent	Upper 1 per cent	Upper 10 per cent	Average
Smith *et al.* (ref. 3)	Emission spectrograph	6·08	—	—	10·54	8·6
King and Wootton (ref. 4)	Oxalate precipitation and titration with potassium permanganate	9·0	9·6	10·8	11·4	10·0
Elliott and Pearson (ref. 5)	Oxalate precipitation and spectrophotometric determination with excess potassium permanganate	10·6	—	—	14·6	11·8
Tammelin and Morgensen (ref. 1)	Spectrophotometric determination of calcium murexide complex	7·6	8·0	9·8	10·7	8·9

working standard calcium solution was obtained thus :

$$\frac{\text{Reading of (Ca Std.–Blank)}}{\text{Reading of (Serum Std.–Blank)}} \times \text{Ca conc. of Serum Std. mgm. per 100 ml.}$$

The corrected value of the working standard calcium solution is now used instead of the value 9 for the calculation of the calcium concentration of test sera.

The standard serum is used as the control for the method[2].

The normal serum calcium range varies with the technique employed for its determination (Table 1). It has been found that the murexide techniques give lower results than oxalate precipitation methods[6,7]. This was verified in this series. The range quoted by King and Wootton[4] is the accepted one, and, in order to avoid confusion, the results obtained with murexide techniques must be corrected in order to bring them into agreement with oxalate precipitation methods. Eldjarn, Nygaard and Sveinsson[7] found that the best agreement was obtained when their values were multiplied by a factor of 1·046. The method of correction adopted here is considered to be satisfactory because the subsequent results were in close agreement (± 1 per cent) with those obtained when using the oxalate precipitation method described by King and Wootton[4] and also with various batches of standardized sera which were afterwards used as controls.

The method gives accurate and reproducible results (± 1 per cent), for this has been proved when using the various batches of standardized sera. However, the results obtained with simpler instruments will not be as accurate as those obtained with the spectrophotometer. The method was also tested on two other instruments : (1) the 'Spekker' photoelectric absorptiometer using the Ilford spectrum filter blue-green (603), and (2) the Gallenkamp direct-reading photoelectric colorimeter using the Ilford bright spectrum blue-green filter (623) ; an optical glass block is inserted into the 1-cm. cuvettes in order to obtain mid-scale readings. The errors with these instruments were ± 2 and ± 3 per cent respectively.

I am indebted to Dr. C. C. Bowley and Dr. J. Darnborough of the Sheffield Regional Blood Transfusion Service Laboratories for the generous supply of sera and to Dr. D. W. Auchinachie, principal biochemist of the City General Hospital, Sheffield, for his advice and encouragement.

[1] Tammelin, L. E., and Morgensen, S., *Acta Chem. Scand.*, **6**, 988 (1952).
[2] Wootton, I. D. P., *Clin. Chem.*, **3**, No. 4, Pt. 2 Supp., 401 (1957).
[3] Smith, R. G., Craig, P., Bird, E. J., Boyle, A. J., Iseri, L. T., Jacobson, S. D., and Myers, G. B., *Amer. J. Clin. Path.*, **20**, 263 (1950).
[4] King, E. J., and Wootton, I. D. P., "Micro Analysis in Medical Biochemistry", 3rd edit., 2 (Churchill, London).
[5] Elliott, J. B., and Pearson, P. B., *J. Lab. Clin. Med.*, **31**, 1262 (1946).
[6] Lehmann, J., *Scand. J. Clin. Lab. Invest.*, **5**, 203 (1953).
[7] Eldjarn, L., Nygaard, O., and Sveinsson, S. L., *Scand. J. Clin. Lab. Invest.*, **7**, 92 (1955).

EFFECT OF RADIATION ON THE BREAKDOWN OF HOMOGENEOUS FIELD AND SPHERE GAPS

By K. R. ALLEN and DR. K. PHILLIPS

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IN the course of some experiments with homogeneous-field electrodes separated by 1 cm. in nitrogen at atmospheric pressure, to which was applied a positive d.c. voltage of 30 kV., it was found that the rate of breakdown increased when the gap was irradiated. Rogowski and Wallraff[1] found that radiation, which would produce a current of 5×10^{-12} amp./cm.^{2} in a spark gap, would reduce the minimum breakdown voltage by about $\frac{1}{2}$ per cent for a gap of 1·5 cm. between spheres at atmospheric pressure.

A quantitative investigation of this effect has been carried out using homogeneous-field electrodes mounted in a glass chamber. The voltage was obtained from a positive high-voltage d.c. source accurately stabilized and controlled by means of a helical potentiometer. After an initial warm-up period, the drift in voltage was found to be approximately 1 part in 5,000 per hr. A 0·001-microfarad condenser was charged through a 100-MΩ resistor, which was in turn connected to one electrode by a 10-MΩ resistor. This arrangement ensured that, when a spark occurred in the chamber, the voltage was chopped and the condenser had to recharge before another spark could occur. The number of discharges per minute was counted for different values of applied voltage for electrode gaps of 1 and 2 cm. at pressures of 76 cm. and 38·8 cm. of mercury in air. The source of radiation was 0·1 mgm. of radium in a nickel pellet situated at (*a*) 30 cm. from

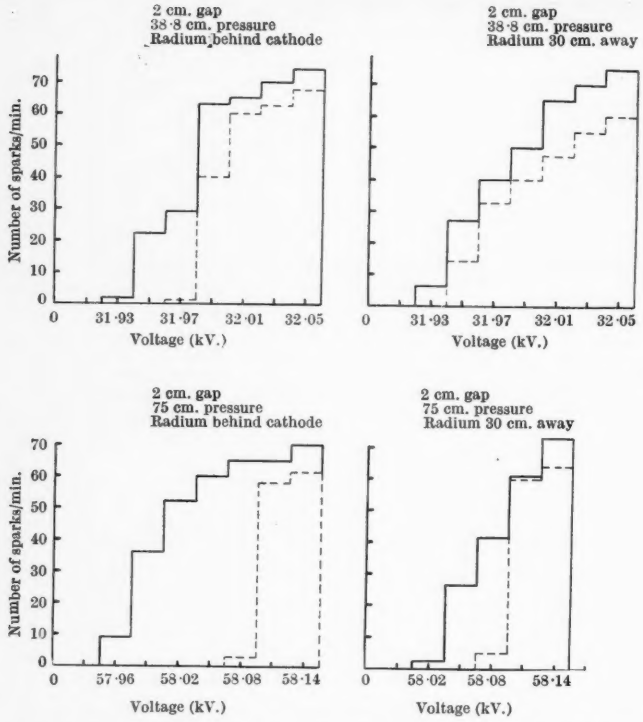

Fig. 1. Histograms showing the variation of the number of sparks/min. with voltage for a 2-cm. homogeneous field gap for different amounts of irradiation and at different air pressures

the gap and (*b*) immediately behind the earth electrode. For each applied voltage, spark counts were taken alternately with and without radiation for 1-min. periods. An example of the results is given in the form of histograms in Fig. 1 for a 2-cm. gap. The dotted histograms give the rate of breakdown without irradiation. In all cases there is an increase in the number of sparks per minute when the gap is irradiated, and there are larger differences between the spark counts as the intensity of irradiation is increased. This increase is more pronounced at atmospheric pressure.

A comparison has also been made between the performance of spheres and plane electrodes, and the results for weak irradiation are shown in Fig. 2. The breakdown voltage of a uniform field gap of 1 cm. was about 2 per cent less than for the same spacing between 5-cm. spheres, and for the experiment the separation of the spheres was reduced to 0·975 cm. so that both gaps broke down at the same voltage. The gaps were connected in parallel and placed so that the radium was 30 cm. from both. The apparent reduction of the breakdown voltage by irradiation was only about 0·1 per cent for the uniform field, but it was about 1 per cent for the spheres. The histogram for the latter also shows that the counting-rate increased relatively slowly with voltage. As a result of this, it is more difficult to determine the minimum breakdown voltage for sphere gaps, and it is necessary to define the intensity of radiation and also the sparking-rate for the minimum breakdown voltage quoted.

The current in the uniform gap when the radium was immediately behind the cathode was about 10^{-11} amp./cm.^{2}, and this would possibly cause some distortion of the field. When the radium was 30 cm. from the gap, the current was several orders of magnitude less, and it seems unlikely that distortion of the field would then occur. The obvious explanation is that irradiation produces more avalanches, resulting in an increased density of positive ions and leading to breakdown when it reaches a critical value. Since the histograms for the irradiated and unirradiated gaps are very similar in shape, it seems reasonable to assume that the breakdown mechanism is the same in both cases, and depends on the successive growth of avalanches across the gap. This is effectively the Townsend mechanism of multiple-avalanche production, but without necessarily having recourse to a γ-mechanism. Evidence in support of this explanation is afforded by observations of avalanche growth in a cloud chamber. Here it was found that 'curtains' of avalanches originated from the ionization produced by an electron track within the gap. If several such curtains are formed in a time less than that required for positive ions to diffuse out of the gap, then the density of positive ions will build up rapidly. The density of positive charge is a significant factor and explains why the irradiation has less effect at lower pressures.

If one considers the field distribution across a sphere gap, the effect on α is to reduce its value in the mid-gap region. Consequently, avalanches beginning to grow from the cathode may not reach the anode if α falls to a low value. On the other hand,

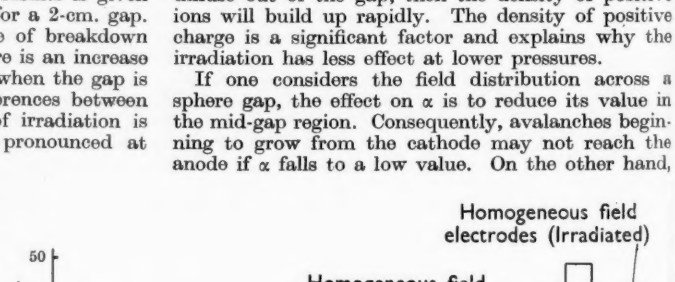

Fig. 2. Comparison between the number of sparks/min. for homogeneous field and sphere gaps of 5 cm. diameter. 1 cm. homogeneous field gap and 0·975 cm. sphere gap. 76 cm. pressure. Radium 30 cm. away.

mid-gap avalanches will grow to the anode in a region of increasing field. If the value of αd is calculated for an avalanche crossing half the non-uniform field gap of 1 cm. between spheres of 5 cm. radius, it is found that the value of X/p required to give equal values of αd is several per cent greater for the spheres. This effect is connected with the phenomenon known as the Toepler[2] discontinuity, and has been studied in detail by Claussnitzer[3].

The relatively slow increase in counting-rate with voltage for sphere gaps can be explained as follows. The value of α across a uniform field is constant, whereas in a sphere gap α has a greater value near the electrodes than in the middle. Therefore, as X/p is reduced in the first case, α rapidly changes from a value which is sufficient to maintain ionization growth to a value which cannot support such growth. In the second case, as X/p is reduced, there is a larger range in which α is sufficient to produce ionization growth. It has been observed that the slope of the counting-rate curve is affected by the presence of water-vapour; results will be reported later. No correction has been made for the effect of humidity, but since the measurements are relative such a correction was considered unnecessary.

The greater effect of irradiation in the case of spheres can be explained as being a volume effect. The average ionization produced by natural causes is about 10 electrons/c.c./sec. In a sphere gap the effective volume for avalanche growth is small; hence any artificial sources of radiation will add to the low value already existing, whereas the uniform field can be assumed to be sufficiently irradiated by natural sources. Here again the fact that α varies across the gap explains why the voltage can be reduced further with irradiation in a sphere gap than in a uniform field. If the voltage is reduced by a small amount and α drops to less than a minimum value, no reasonable amount of irradiation will cause the uniform-field gap to break down.

[1] Rogowski and Wallraff, *Z. Phys.*, **97**, 758 (1935).
[2] Toepler, *Elektrotech. Z.*, **53**, 1219 (1932).
[3] Claussnitzer, *Elektrotech. Z.*, **57**, 177 (1936).

HEPARIN AND THROMBOPLASTIN GENERATION IN THE HORSE

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A SERIES of experimental ponies were injected intravenously with 250 I.U. per kilogram of heparin ('Liquemin'; Roche) and a number of observations made on these animals. The horse has at least one appreciable experimental advantage, in that it is possible to remove relatively large volumes of blood at frequent intervals without materially affecting the physiological *status quo*. The purpose of this communication is to enlarge upon a thromboplastin generation defect which was observed.

The expected prolongation of clotting time in glass tubes at 37° C. was accompanied by prolongation of the one-stage plasma prothrombin time, using either horse brain thromboplastin or Russell's viper venom. There was a concurrent defect in thromboplastin generation. With the exception of the test using Russell's viper venom all these abnormalities extended over a period of five hours after the injection (Fig. 1).

Thromboplastin generation tests were performed according to the method of Biggs and Douglas[1], modified by replacing platelets by a chloroform extract of acetone-dried horse brain[2], and using only horse blood in the preparation of the solutions. Alumina plasma was prepared from high-spun citrated plasma with a very low platelet content. A typical series of results is shown in Fig. 2. In the preparation of each curve alumina plasma, serum and substrate plasma were each derived from the appropriate blood specimen. The experiments were performed upon six ponies.

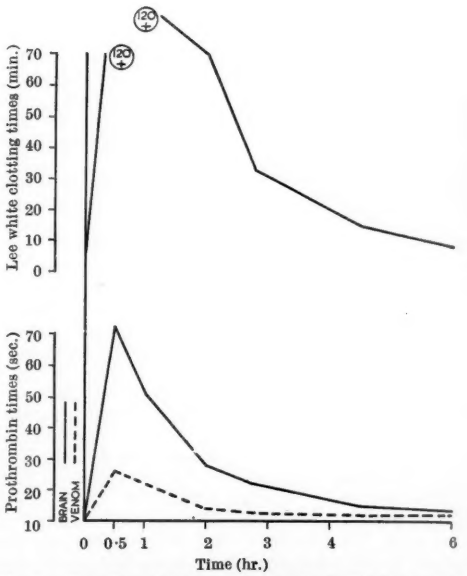

Fig. 1. The effect of intravenous heparin in the horse upon whole blood clotting time; and the 1-stage prothrombin time using either brain extract or Russell's viper venom as the thromboplastic source

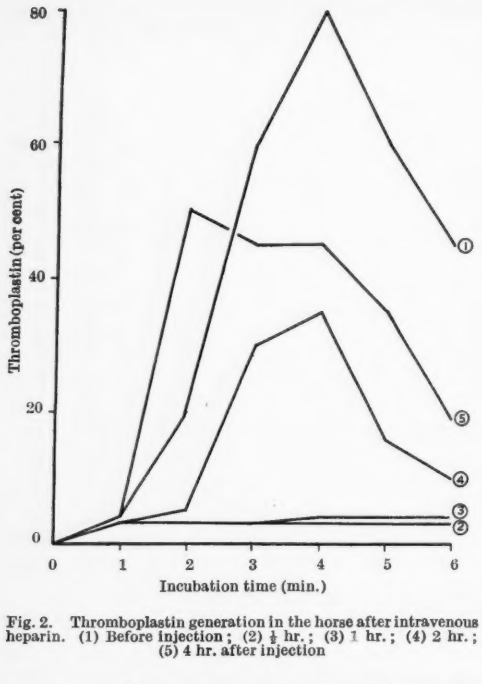

Fig. 2. Thromboplastin generation in the horse after intravenous heparin. (1) Before injection; (2) ½ hr.; (3) 1 hr.; (4) 2 hr.; (5) 4 hr. after injection

It was possible to demonstrate that plasma taken 2 hr. or more after the injection of heparin reacted equally as well as normal horse plasma when used as substrate in the test. The persistent defect in curves 4 and 5 therefore represents a failure of thromboplastin generation rather than a failure to react with formed thromboplastin. Subsequent attempts to define the nature of this defect were confined to specimens taken at 2 hr. or afterwards.

Substitution of either normal alumina plasma or normal serum in a system otherwise derived from the 2-hr. post-injection specimen gave an increase in thromboplastin formation in each case, though this was usually greater when normal serum was used. Thus a defect in both alumina plasma and serum activity was detected.

The addition of 0·1 ml. of saline, or saline containing other reagents at various dilutions, to a system wholly derived from the 2-hr. post-injection specimen was next investigated. Complete correction could not be achieved. Normal horse alumina plasma corrected the deficiency to 60 per cent of normal at an optimal original dilution of 1 : 5; normal serum corrected to 70 per cent at 1 : 10 original dilution; a preparation of Christmas factor from horse serum[3], shown to be as active as normal human serum in replacing the defect in a human subject with severe Christmas disease, gave only 40 per cent correction at a 1 : 20 original dilution. Normal horse serum previously adsorbed with a suspension of aluminium hydroxide gave the best overall correction, usually 80 per cent at a 1 : 10 original dilution.

These results in the horse differ from those reported in humans. Following the injection of heparin into human volunteers, O'Brien[4] has described a deficiency in thromboplastin generation corrected by normal serum but not by Christmas disease serum or by alumina-adsorbed serum. Normal alumina-adsorbed human serum and alumina-adsorbed serum from a case of severe Christmas disease were as effective as horse alumina serum in the correction of the defect in the horse.

Conversely, in one experiment, plasma from the 2- and 4-hr. experiments was equally as active as normal horse plasma in replacing the deficiency in the plasma of a human subject with classical hæmophilia (hæmophilia *A*). The 2-hr. specimen had only 25 per cent, and the 4-hr. 45 per cent, of the ability of normal horse blood to replace the deficiency of a human subject with Christmas disease (hæmophilia *B*).

Using Russell's viper venom as a source of thromboplastin the one-stage times of the 2- and 4-hr. plasma specimens were normal, though the defect seen using horse brain thromboplastin still persisted. This suggests that the latter may be accounted for by a deficiency of factor VII[5].

It has been demonstrated[6–8] that the horse coagulation system resembles that of humans in many respects. Since the defect in thromboplastin generation produced by heparin is corrected by alumina adsorbed serum, a deficiency of factors thought to be present in adsorbed human serum must be considered.

Factor X and Stuart-Prower factor, which may be identical[9], are associated in man with a deficiency of both thromboplastin generation and the one-stage prothrombin time using Russell's viper venom[10]. These may be present in alumina serum, but as the Russell's viper venom time has been shown to be normal while thromboplastin generation remains deficient, they are unlikely to give rise to the defect described here.

Human plasma exposed to contact with glass shows accelerated clot formation[11]. Failure to react normally to contact with glass, together with failure of thromboplastin generation, is seen in humans deficient in either Hageman factor or plasma thromboplastin antecedent[12]. Both these factors are known to be present in alumina-adsorbed serum as well as in serum and in alumina-plasma. Glass contact has been shown to activate factor VII and Christmas factor[13], and human cases deficient in plasma thromboplastin antecedent behave as if they have a deficiency of Christmas factor activity[12].

If a similar reaction to contact with glass, dependent upon factors with similar properties, exists in the horse then the findings after heparin injection might be interpreted as a failure to react normally to contact with glass. Further investigations of the ability of normal horse plasma to react to contact with glass is necessary before these observations can be fully interpreted.

[1] Biggs, R., and Douglas, A. S., *J. Clin. Path.*, **6**, 23 (1953).
[2] Bell, W. N., and Alton, H. G., *Nature*, **174**, 880 (1954).
[3] White, S. G., Aggeler, P. M., and Glendening, M. B., *Blood*, **8**, 101 (1953).
[4] O'Brien, J. R., *Nature*, **181**, 1801 (1958).
[5] Biggs, R., and MacFarlane, R. G., "Human Blood Coagulation and its Disorders", 2nd edit. (Blackwell Scientific Publications, Oxford, 1957).
[6] Bell, W. N., Tomlin, S. C., and Archer, R. K., *J. Comp. Path.*, **65**, 255 (1955).
[7] Barkhan, P., Tomlin, S. C., and Archer, R. K., *J. Comp. Path.*, **67**, 358 (1957).
[8] Fantl, P., and Marr, A. G., *J. Physiol.*, **142**, 197 (1958).
[9] Koller, F., Duckert, F., Bachmann, F., Streuli, F., and Geiger, M., Proc. Sixth Congr. Europ. Soc. Hæmat., Copenhagen, 1957 (in the press).
[10] Dische, F. G., *Brit. J. Haemat.*, **4**, 201 (1958).
[11] Margolis, J., *J. Physiol.*, **137**, 95 (1957).
[12] Biggs, R., Sharp, A. A., Margolis, J., Hardisty, R. M., Stewart, J., and Davidson, W. M., *Brit. J. Haemat.*, **4**, 177 (1958).
[13] Owren, P. A., Rapaport, S. I., Hjort, P., and Aas, K., *Sang*, **25**, 752 (1954).

REDUCTION IN THE LETHAL EFFECTS OF RADIATIONS ON *ESCHERICHIA COLI B* BY TREATMENT WITH CHLORAMPHENICOL

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MANY procedures have been reported for bringing about 'recovery' in *Escherichia coli B* after irradiation. Alper and Gillies[1] found that the observed sensitivity of this strain to both ultra-violet and ionizing radiations was very dependent on methods of culture, and that survival of the irradiated bacteria was least in those conditions in which the non-irradiated bacteria grew fastest. This suggested that inhibition of some metabolic step, for a limited period after irradiation, might lead to increased survival of the irradiated bacteria. Since chloramphenicol has been reported to inhibit protein synthesis[2], its effect on irradiated cells of *E. coli B* has been investigated. It has been found that the lethal effects of both X-rays and ultra-violet light are greatly reduced if the bacteria are incubated for a period after irradiation on solid medium containing chloramphenicol (5 μgm./ml.). We believe that no post-irradiation treatment reported hitherto has been as effective in reducing the observed sensitivity to X-rays.

Survival of the bacteria was determined by counting colonies which grew on 'Cellophane' carriers lying on the surface of nutrient agar ('Oxoid' blood agar base). The use of these carriers throughout the experiments permitted rapid transfer of irradiated or control cells from one medium to another, so that they could be removed from contact with the chloramphenicol without the necessity for washing and centrifuging. The methods of preparing bacterial suspensions for irradiation, and of dispensing aliquots on to the 'Cellophane' carriers, have been previously described[1]. Ultra-violet irradiations were carried out with the bacteria spread on pieces of 'Cellophane' lying on the surface of agar gel containing no nutrients. In the X-ray experiments the bacteria were irradiated in liquid suspension, in the presence and absence of oxygen, by methods which ensured control of the dissolved gases[3]. Transfers to nutrient medium, with or without chloramphenicol, were made as soon as possible after irradiation, and all plates were warmed to 37° before transfer. Colony counts were made after a final incubation period of at least 15 hr. on nutrient medium, and treatments of irradiated bacteria were always matched by the same treatment of controls, which were found to yield a constant count irrespective of the length or timing of the incubation period on chloramphenicol–agar.

The X-ray experiments were carried out on stationary-phase suspensions only. Dependence of the surviving fraction on the period of incubation on chloramphenicol–agar is illustrated by Fig. 1. With no chloramphenicol treatment, a dose of 19 kilorads delivered in anoxic conditions reduced the population to the same fraction as a dose of 9·9 kilorads delivered under oxygenation. It may be seen that the 'rescue' by chloramphenicol treatment was considerably greater after irradiation in anoxic conditions. Incubation for 3 hr. on chloramphenicol–agar immediately after irradiation increased the surviving fraction by a factor which corresponded to a twofold reduction in the effectiveness of the X-rays delivered in the presence of oxygen, and a fourfold reduction in anoxic conditions. The factor by which oxygen was observed to enhance the effect of radiation was only about two, if surviving fractions were compared when the bacteria were placed immediately on nutrient agar. This ratio was roughly doubled, however, if the observations were made on surviving fractions after 3 hr. of chloramphenicol treat-

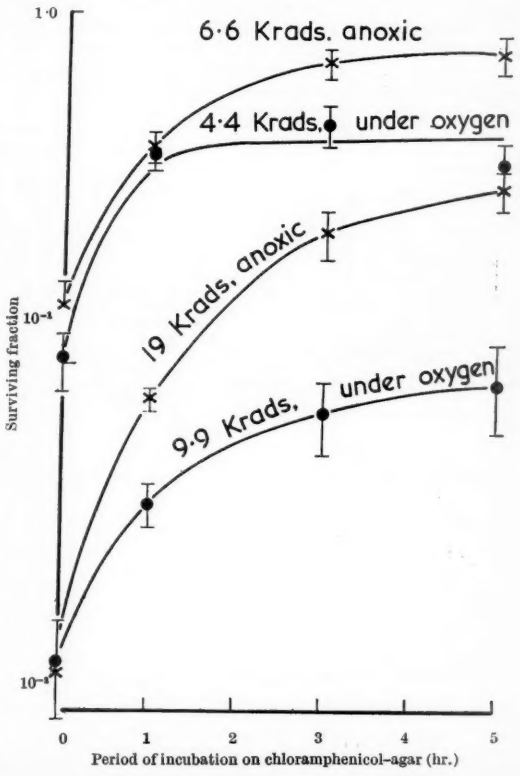

Fig. 1. Dependence of surviving fraction of X-irradiated *E. coli B* (stationary phase) on period of incubation on chloramphenicol–agar

ment. These results confirm our previous report[4] that the enhancing action of oxygen is exerted mainly on a fraction of the damage not affected by post-irradiation conditions. When these are of a nature to reduce overall sensitivity, the observed effect of oxygen is increased.

The dependence of surviving fraction on the period of incubation on chloramphenicol–agar, after ultra-violet irradiation at 2537 A., followed roughly the same course as that illustrated in Fig. 1, when stationary phase bacteria were used. An interesting difference was observed, however, when bacteria in the logarithmic phase were exposed to ultra-violet light. As shown in Fig. 2, short periods on chloramphenicol led to a decrease in the number of colonies formed by bacteria irradiated in the logarithmic phase. This suggests that the initial inhibitory action of chloramphenicol enhances the effect of the radiation, and that a secondary, and more complete, inhibition of metabolism enables many of the cells to proceed successfully to division, after they have been removed from the chloramphenicol.

Survival of both ultra-violet- and X-irradiated bacteria could be still further increased if the irradiation was followed by a preliminary period (up to 1 hr.) on nutrient agar, before commencement of the chloramphenicol treatment. This was found to eliminate the initial decrease in surviving fraction observed with logarithmic phase bacteria. The effects of preliminary incubation on nutrient agar combined with varying periods of chloramphenicol treatment are illustrated in Fig. 3. It can be seen that after a dose of ultra-violet light which reduced the surviving fraction of untreated bacteria to 8×10^{-3}, samples which were incubated for 1 hr. on nutrient agar, then for 2 hr. on the medium containing chloramphenicol, and finally overnight on

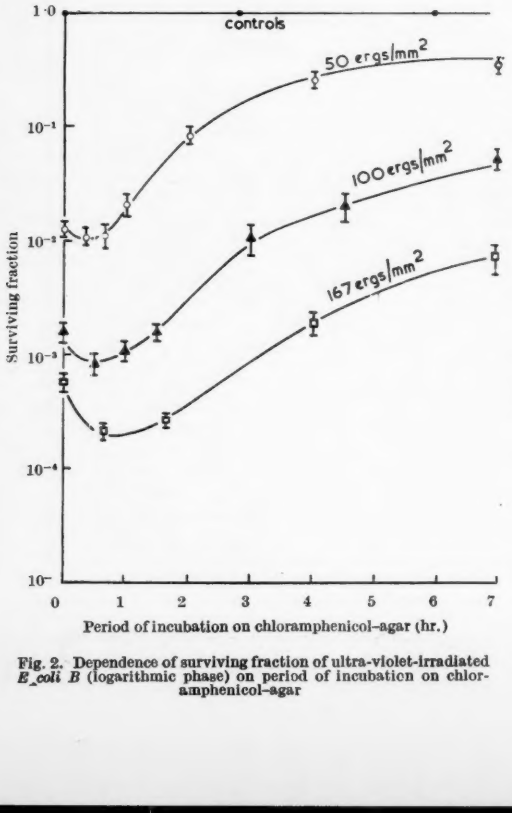

Fig. 2. Dependence of surviving fraction of ultra-violet-irradiated *E. coli B* (logarithmic phase) on period of incubation on chloramphenicol–agar

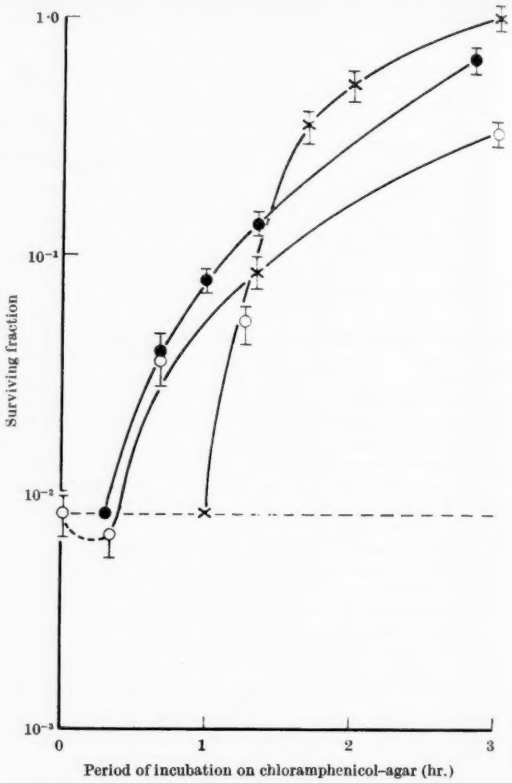

Fig. 3. Dependence of surviving fraction of ultra-violet-irradiated *E. coli B* (50 ergs/mm.², logarithmic phase) on period of incubation on chloramphenicol–agar

○, on chloramphenicol–agar immediately after irradiation; ●, on nutrient agar for 20 min. after irradiation; ×, on nutrient agar for 1 hr. after irradiation

nutrient medium, formed as many colonies as the control unirradiated suspension. Thus virtually all the effect of this dose of ultra-violet light appears to be due to a metabolic disturbance, the effects of which may be counteracted by the inhibitory action of the chloramphenicol. When stationary-phase bacteria were used, chloramphenicol treatment applied in the same way increased the surviving fraction from 4×10^{-3} to 0·85. In a comparable experiment with X-rays delivered in anoxic conditions, the surviving fraction increased from $7{\cdot}3 \times 10^{-3}$, for bacteria plated on nutrient agar, to about 0·55, after chloramphenicol treatment following 1 hr. preliminary incubation on nutrient medium. Thus a smaller fraction of the overall effect of X-rays is attributable to the metabolic disturbance which is mainly responsible for the lethal effect of ultra-violet light on *E. coli B*.

We wish to record our appreciation of the assistance given by Miss Brenda Hodgkins with these experiments.

[1] Alper, T., and Gillies, N. E., *J. Gen. Microbiol.*, **18**, 461 (1958).
[2] Gale, E. F., and Folkes, J. P., *Biochem. J.*, **53**, 493 (1953). Wisseman, C. L., Smadel, J. E., Hahn, F. E., and Hopps, H. E., *J. Bact.*, **67**, 662 (1954). Harrington, M. G., *J. Gen. Microbiol.*, **18**, 767 (1958).
[3] Howard-Flanders, P., and Alper, T., *Radiation Res.*, **7**, 518 (1957).
[4] Alper, T., and Gillies, N. E., *Nature*, **181**, 961 (1958).

LETTERS TO THE EDITORS

ASTRONOMY and ASTROPHYSICS

Volcanoes on the Moon

For some time, opinion on the origin of the Moon's craters has been hardening in favour of the meteoric theory and against the volcanic. The recent observation of volcanic activity by Dr. Kozyrev has, in some quarters, produced a reaction in favour of the volcanic origin. I would like to suggest that this reaction is unnecessary.

Whatever is the origin of the craters it is possible that they may be filled with dust to considerable depths. The thermal conductivity of dust, in a good vacuum, and under a low gravitational pull, is likely to be extremely low, owing to the small areas of actual contact between the particles. It may be supposed that this area of true contact between adjacent particles depends only on the force between the two particles and on the yield-strength of the material composing them. In a thick layer of dust, the force between particles of given size will increase linearly with depth from the surface and hence so will the area of true contact. Suppose the mean density is ρ gm. cm.$^{-3}$. Then at depth h cm. the pressure is ρgh dynes/sq.cm. If the compressive yield-strength of the material is s dynes/sq.cm., the contact-areas in each column of particles will be only $\rho gh/s$ of the cross-sectional area of the column.

The effect of this on the conductivity will depend on the shapes of the particles before deformation. If we use the drastic simplification of supposing the particle contacts to be derived from pyramidal points crushed on to plane surfaces, we find that the effective conductivity k_e is given approximately by $2k\sqrt{\rho gh/s}$ when the quantity $\rho gh/s$ is small, k being the thermal conductivity of the solid material. If we suppose the material forming the dust to be a fairly hard rock (Mohs' scale 6 or Vickers' hardness 700 kgm./mm.^{2}) with thermal conductivity 5×10^{-3} cal. cm.$^{-1}$ deg. C.$^{-1}$, and take g to be 160 cm. sec.$^{-2}$, this gives a value of k_e of about $7 \times 10^{-7}\sqrt{h}$. At 100 m. in the case considered, the conductivity might be around 1/70 of the bulk value or, at 1 m., 1/700 of the bulk value. Owing to the multiplicity of reflecting surfaces, the contribution of radiation can be neglected, and gas conduction, important in more familiar circumstances, is zero.

In such conditions the importance of the Moon's natural radioactivity may be high, although, owing to the Moon's small size, it has usually been thought less important than that of the Earth. Suppose that this is equivalent to 2 parts per million of uranium—appreciably less than the equivalent total activity of the Earth's crust. An isolated piece of such material will then show a temperature rise in the region of 8 deg. C. per million years. Since the conductivity of hot rock is fairly high, the interior of the Moon is likely to have reached an equilibrium temperature some time ago. In equilibrium conditions the heat flux reaching the surface must be the whole of that produced in the interior. This will give about 260 calories per year per cm.^{2} or $8{\cdot}4 \times 10^{-6}$ cal./sec./cm.^{2}. Then if T is the difference between the temperature at depth h and the mean surface temperature:

$$\delta T = \frac{8{\cdot}4 \times 10^{-6}\,\delta h}{7 \times 10^{-7}\sqrt{h}} \text{ deg. C.}$$

$$\text{so } T = 24\sqrt{h} \text{ deg. C.}$$

At 1-m. depth this is already 240° C. It will reach the softening point of, for example, basalt at about 25 m. depth if we neglect changes in properties with temperature. In other words, dust could not lie indefinitely over large areas to depths of more than about 25 m. With a thickness of only a few metres, conduction to the sides of a crater kilometres across will be as important as conduction through the dust. Even if the craters were not formed by volcanic action, however, the mere filling of the larger ones with dust would provide, in time, for volcanic activity in the centres.

It is unlikely that enough material would be involved in any one eruption to cause the ejection of major quantities of liquid or solid. The very low mechanical pressure of the dust would seem rather to encourage frequent small local instabilities due to high-temperature release of gases. These instabilities would result in periodic liberation of puffs of hot gas and dust just as the slow liberation of marsh gas leads to occasional bursts of mud and gas from the bottom of a stagnant pond. 'Frequent' here means many times per million years. The phenomenon would therefore appear analogous to boiling with bumping rather than to volcanic action on the Earth's surface, and would produce just the kind of phenomenon which has been observed. It is not so likely that it could be responsible for the central peaks which are often observed in the larger craters.

I am indebted to Mr. F. R. Stewart of this Department for pointing out that, if this picture of events is even approximately true, a large and fairly accessible source of power should be available to the establishments which will doubtless be set up on the Moon in due course.

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Changes in the Inclination of Satellite Orbits to the Equator

In a recent article[1], we gave some details of changes in the orbital inclination of *Sputnik* 2 (1957β) and suggested that these changes might be caused by the rotation of the atmosphere. Bosanquet has presented an analysis[2] which supports this view, giving fair agreement with the observed changes. We have now completed a more thorough investigation, taking into account the spread of atmospheric resistance around perigee.

If the atmosphere is assumed to rotate with the same angular velocity as the Earth, and the drag force acts along the direction of motion of the satellite relative to the air, the change, Δi, in orbital inclination i is given by:

$$\Delta i = \Delta T \cdot \frac{\sin i}{6} \cdot \frac{(2I_2 - 4e\,I_1)\cos^2\omega + I_0 - I_2 + 0(e^2)}{(1 - T\cos i)\,I_0 + 2e\,I_1} \quad (1)$$

where T is the period of revolution expressed as a fraction of a day, e is the eccentricity of the orbit, ω is the argument of perigee, I_n is the Bessel function of the first kind and imaginary argument of order n and ot argument ae/H, where a is the semi-major axis of the orbit and H is the scale-height of the atmosphere.

It will be noted that Δi is related directly to changes in period ΔT, so that irregularities in air density do not affect the analysis. Also, with $0 < i < 180°$, the inclination i always decreases, so that for a satellite moving from west to east ($0 < i < 90°$) the maximum latitude decreases—this corresponds to the condition for all satellites launched to date—whereas for a satellite moving from east to west ($90° < i < 180°$) the maximum latitude increases.

If the Bessel functions are replaced by their asymptotic expansions, equation (1) reduces to:

$$\Delta i = \Delta T \cdot \frac{\sin i}{3} \cdot \frac{(1 - 15k/8 - 2e)\,\cos^2\omega + k}{(1 - T\cos i)\,(1 + k/8) + 2e} \times \{1 + 0\,(k^2, e^2)\}, \ldots \quad (2)$$

where $k = H/ae$. This expansion is most appropriate, since k and e are of the same order if $0{\cdot}05 < e < 0{\cdot}15$.

Equation (2) shows that the change in i depends mainly on three quantities: (1) i itself—the greater the inclination the greater is the change, because the force due to the rotating atmosphere is more nearly perpendicular to the path; (2) the change in period, ΔT, which is a measure of how much the atmosphere is affecting the orbit in general; (3) the angle ω from equator to perigee, the effect being greatest when perigee is at the equator, where the rotational speed is greatest.

If, in equation (2), the terms in k, e, T are ignored, the equation given by Bosanquet[2] is obtained. For *Sputnik* 2 it is found that the change in inclination obtained from (2) is about 30 per cent less than that given by the simpler equation, and this scarcely justifies the use of the latter.

The theoretical curve for the inclination of *Sputnik* 2, obtained by numerical integration of equation (1), is compared with the observed values in Fig. 1. It appears that the theoretical curve is not quite steep enough. Analysis of observations of the rocket of *Sputnik* 3 (1958δ1) is not yet complete, but a decrease in inclination is apparent, and again the theoretical curve is not steep enough. Its slope would, however, be increased if there were a strong wind from west to east. It is indeed possible, in principle, to determine mean wind speed at height of perigee by measuring the changes in orbital inclination; but this would require more accurate observations than are at present available and a theory which took account of other effects such as the oblateness of the atmosphere. The most that can be said now is that rotation of the atmosphere is responsible for the major part of the observed effect.

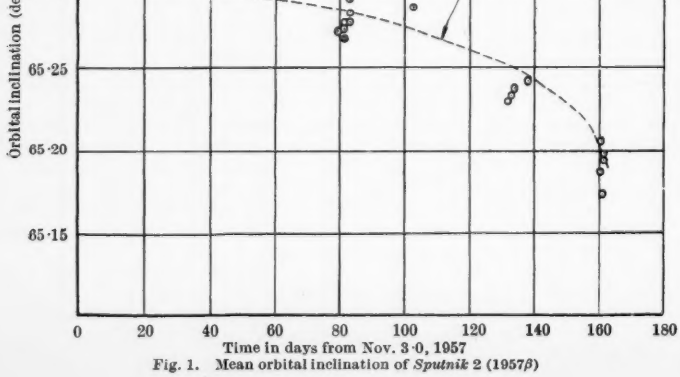

Fig. 1. Mean orbital inclination of *Sputnik* 2 (1957β)

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[1] Merson, R. H., and King-Hele, D. G., *Nature*, **182**, 640 (1958).
[2] Bosanquet, C. H., *Nature*, **182**, 1533 (1958).

'Turbulence' and the Photospheric Granulation

Early high-resolution photographs of the solar photosphere showed a well-defined pattern of bright granules with diameters lying mostly in the range 1–2 sec. of arc. The similarity of this structure to laboratory convection patterns led to the view that the granules represent convective cells of the Bénard type. However, although some modern observers[1–3] apparently confirmed the existence of a granular structure with the same narrow distribution of sizes, others reached contrary conclusions. In particular, on the basis of photometric measurements of photographs obtained at Mt. Wilson, some workers[4–6] have concluded that the solar surface actually presents the appearance of random brightness fluctuations. These brightness fluctuations have been identified with so-called 'turbulent eddies'. In fact, the view is now widely held that the photosphere is in a state of aerodynamic turbulence. (This conclusion has been opposed by Plaskett[7].) This interpretation, however, does not accord with results derived from sequences of high-quality photographs of the granulation obtained recently by Leighton[8] in the United States and by us[9] in Australia. These cinematographic observations strongly support the convective interpretation and argue against the existence of turbulence.

Both sets of observations show the granules as bright features of

various shapes, 1–2 sec. of arc in diameter, which are separated by darker material. The appearance of individual granules persists in detail from photograph to photograph over periods of several minutes. A photograph of superb quality recently published by Rogerson[10] shows a similar pattern: although there are a few features of diameter less than 0·5 sec., the majority of the granules appear to have diameters in the range 1–2 sec. (The dark boundaries appear narrower than on photographs of lesser quality.) These photographs all strongly suggest that the granules are to be identified with convection cells and not with the 'eddies' of any large-scale turbulence.

In addition, the Australian observations support Leighton's hypothesis that the motions within the granules themselves are non-turbulent. The observations are of sufficient quality to enable the development of individual granules (classified according to brightness, size, and shape) to be followed from photograph to photograph over an average period of nearly 7 min. The 125 granules selected for study displayed remarkable stability: 57 per cent showed no detectable change in brightness, size, or shape over this period, an additional 14 per cent showing only minor changes of shape. This stability argues strongly against the existence of aerodynamic turbulence within the granules. The observations are based on photographs contained in a 10-min. sequence, the variable quality of which limited the period over which it was possible to study changes[9]. A longer sequence of better photographs might well show that the stability persists over even longer periods.

Many workers have deduced the existence of 'turbulent' velocities of the order of 2–3 km./sec. from measurements of line profiles and equivalent widths (cf. Waddell[11]). However, these velocities should be regarded as mere parameters indicating the existence of non-thermal motions[12]: they provide no evidence for fully developed turbulence in the strict aerodynamic sense[13]. Moreover, spectroscopic measurements refer to a region of the photosphere lying above the granulation observed in white light; in this region the vertical convection currents may be modified by the onset of radiative cooling (cf. Plaskett[14]).

The available observational evidence thus argues against the existence of turbulence in the photosphere. How far is this conclusion consistent with the known properties of turbulence in gases? It has often been contended that, in view of the high value of the Reynolds number, the solar gases must be turbulent. However, the Reynolds number criterion for the onset of turbulence is an empirical rule, valid in the case of the forced flow of an incompressible fluid through a pipe, but not necessarily applicable to the photosphere. Moreover, turbulence requires for its maintenance a continuous source of mechanical energy[15,16]. In the photosphere the only possible source is the convective motion, which arises from thermal instability. However, if turbulence were present, the consequent transfer of momentum between the upward- and downward-moving columns would tend to destroy the motion, so that the turbulence would be self-damping.

Richardson and Schwarzschild[17], by an erroneous application of Kolmogoroff's law, have even gone to the extent of deriving a complete 'spectrum of turbulence' for the photosphere (cf. Burgers and Thomas[18]). According to Richardson and Schwarzschild the most energetic 'turbulent elements' have a diameter of about150 km. (ref. 17) or 300 km. (ref. 19) (0·2 or 0·4 sec. of arc); these are identified by them with small, very bright granules—so far unobserved. Our observations are not capable of showing structures as small as this. However, they reveal no correlation between the brightness and size of individual granules: in fact, it is found that bright granules are just as likely to be larger as smaller than average.

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[1] Keenan, P. C., *Astrophys. J.*, **88**, 360 (1938).
[2] Macris, C., *Ann. d'Astrophys.*, **16**, 19 (1953).
[3] Miller, W. A., R.C.A. Solar Research Studies, Triannual Report No. 1 (1954).
[4] Frenkiel, F. N., and Schwarzschild, M., *Astrophys. J.*, **121**, 216 (1955).
[5] Skumanich, A., *Astrophys. J.*, **121**, 404 (1955).
[6] Uberoi, M. S., *Astrophys. J.*, **122**, 466 (1955).
[7] Plaskett, H. H., *Mon. Not. Roy. Astro. Soc.*, **114**, 251 (1954).
[8] Leighton, R. B., *Pub. Astro. Soc. Pac.*, **69**, 497 (1957).
[9] Bray, R. J., and Loughhead, R. E., *Aust. J. Phys.*, No. 4 (1958). (in the press).
[10] Rogerson, J. B., *Sky and Tel.*, **17**, 112 (1958).
[11] Waddell, J. H., *Astrophys. J.*, **127**, 284 (1958).
[12] Bhatnagar, P. L., Krook, M., Menzel, D. H., and Thomas, R. N., "Vistas in Astronomy", ed. Beer, A., **1**, 297 (London, 1955).
[13] Pai, S., "Viscous Flow Theory: II—Turbulent Flow", 1 (Princeton, 1957).
[14] Plaskett, H. H., "Vistas in Astronomy", ed. Beer, A., **1**, 644 (London, 1955).
[15] von Kármán, T., "Problems of Cosmical Aerodynamics", 131 (Central Air Documents Office, Dayton, Ohio, 1951).
[16] Townsend, A. A., "The Structure of Turbulent Shear Flow", 1 (Cambridge, 1956).
[17] Richardson, R. S., and Schwarzschild, M., *Astrophys. J.*, **111**, 351 (1950).
[18] Burgers, J. M., and Thomas, R. N., *Rev. Mod. Phys.*, **30**, 909, 1105 (1958).
[19] Schwarzschild, M., *Trans. Internat. Astro. Union*, **9**, 738 (1955).

PHYSICAL SCIENCES

Emission of Slow Secondary Electrons

In a recent paper[1] measurements of the probabilities of multiple emissions of secondary electrons are reported. These indicate that emission of at least some secondary electrons depends on interaction between the primary electron and the solid plasma as a whole, the co-operative interaction[2] as opposed to the individual interaction of current theories[3].

The main points to be explained are: (1) the existence of a group of slow secondaries in a continuous energy-range about 1 eV., nearly independent of the material and of bombardment conditions; (2) the emission of secondaries within 2×10^{-10} sec. following the primary impact[4]; (3) the steep rise of the secondary emission coefficient to a maximum at a primary energy of about 200 eV. followed by a slow fall as primary energy is increased[5]. These facts are consistent with a process for which the classical analogue is the fall of a drop into a body of liquid. As is well known, the reaction of the liquid forces a globule on a narrow neck well above the free surface of the liquid.

In secondary emission, injection of a primary across the boundary will result in transient motions of the negative charge cloud such that a high local negative charge density forms about the point of entry after

a time of the order of the period of the plasma oscillation (about 10^{-15} sec.). The rise of this density forces electrons successively over the work-function barrier and accelerates them only slightly after ejection. Such secondaries will be instantaneous to a degree beyond experimental requirements, nearly independent of the detailed properties of the primary, of low emission velocity since acceleration after emission is due at most to a few electron charges. Emission energies will cover a continuous range since acceleration will depend on the rate of build-up of surface charge after ejection, that is, on the phase of the plasma cycle at ejection.

At low primary velocities little energy will be transferred to the plasma since the charge cloud can adjust itself to equilibrium with the moving charge at all stages. Maximum energy will be transferred when the primary electron travels one interaction distance within the plasma in a time of the order of the plasma cycle. Above this velocity energy transfer will fall slowly. Quantum mechanical description of the process is likely to be difficult.

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[1] Barrington, R. E., and Anderson, J. M., *Proc. Phys. Soc.*, **72**, 717 (1958).
[2] Bohm, D., and Pines, D., *Phys. Rev.*, **92**, 609 (1953).
[3] Bruining, H., "Secondary Electron Emission" (Pergamon Press, 1954).
[4] Wang, C. C., *Phys. Rev.*, **68**, 284 (1945).
[5] Cowan, J. A., *Can. J. Phys.*, **32**, 101 (1954).

Changes in Transition Probability due to the Interaction of Rotation and Vibration in Diatomic Band Spectra

The distributions of rotational and vibrational intensities in band spectra are frequently used for measurement of effective temperatures in, for example, flames[1] and stellar spectra. In such calculations it has become customary to treat independently the derivation of rotational and vibrational transition probabilities, although the possibility of error has been noted[2,3]. Major errors attributed to an interaction occur with the weak (0, 1) band of OH at 3428 A. as shown by the incompatible rotational 'temperatures' obtained from a plot such as Fig. 1, calculated on the assumption that only rotational transition probability affects intensity within a band. The gradients of the three straight lines correspond to temperatures of 2,290, 1,420 and 750° K. for R, Q and P_1 branches respectively. The curved portions at low energies are due to unresolved satellite branches. Similar treatment of a stoichiometric flame, using the intensities of Bass and Broida[4], give for the (0,1) band R branches a temperature of 4,180° K., and for the P branches 1,380° K.; even the S branch of the (0,0) band at 3064 A. gives 3,560° K. The estimated temperature of the flame was 2,750° K. Further discrepancies for other bands of the system have been reported[5]. The (0,1) band is very weak, and these effects cannot be attributed to self-absorption.

Rotational transition probabilities are derived from statistical considerations. Vibrational ones are based on the Franck–Condon principle and are derived by calculating the overlap integrals of the vibrational wave-functions; they thus depend on the forms of

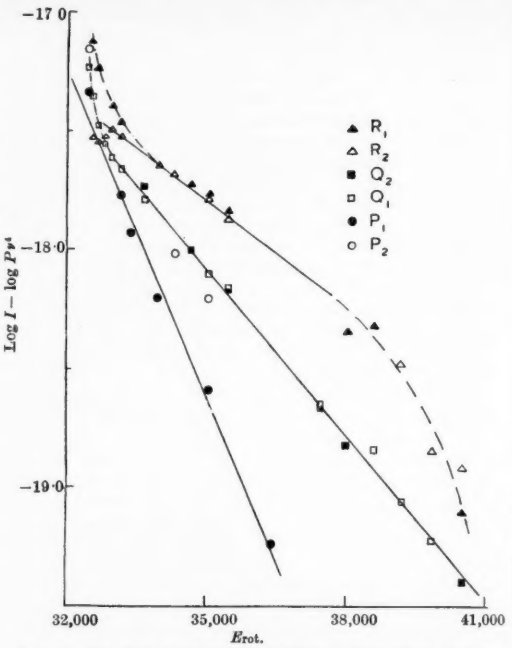

Fig. 1. The (0,1) band of OH at 3428 A. Log $I/P\nu^4$ plotted against the energy of the rotational level from which a transition, intensity I, frequency ν, originated. Source: a hydrogen-rich H_2/O_2 flame at atmospheric pressure, photographed on a large quartz spectrograph of dispersion 4 A. per mm.

the two potential energy-curves. When rotation is taken into account the potential curves are modified by adding a term in $J(J+1)/r^2$. Fig. 2 shows curves for the rotational levels $J = 1\frac{1}{2}$ and $J = 20\frac{1}{2}$, and it is seen that the minima are displaced to larger internuclear distances, especially for the upper, $^2\Sigma^+$, state. This displacement modifies the overlap integrals.

We have made calculations of these overlap integrals using wave functions for a Morse–Pekeris oscillator, including rotation[6], and obtain the following transition probabilities:

(0,0) band	P_1 (1)	1·00	P_1 (20)	0·96
	Q_1 (1)	1·00	Q_1 (20)	0·94
	R_1 (1)	1·00	R_1 (20)	0·91
(0,1) band	P_1 (1)	0·11	P_1 (20)	0·12
	Q_1 (1)	0·11	Q_1 (20)	0·15
	R_1 (1)	0·11	R_1 (20)	0·17

Assuming[7] that the electronic transition moment is proportional to e^{-3r} these become:

(0,0) band	P_1 (1)	1·01	P_1 (20)	0·74
	Q_1 (1)	1·00	Q_1 (20)	0·71
	R_1 (1)	0·99	R_1 (20)	0·67
(0,1) band	P_1 (1)	$0·01_4$	P_1 (20)	$0·01_8$
	Q_1 (1)	$0·01_7$	Q_1 (20)	$0·02_3$
	R_1 (1)	$0·01_8$	R_1 (20)	$0·03_3$

It will be seen that for the (0,0) band the changes of vibrational transition with rotational quantum number or branch type are relatively small but, assuming a linear relationship, the change of slope would still cause a difference in temperature of 300° at 3,000° K. For cases such as the (0,1) band where the overlap integral is very small the effect of rotation and of branch type becomes really important.

The results for the (0,1) band are extremely sensitive to the difference $(r_e' - r_e'')$, a change of 0·1 per cent in either r_e causing a change of 10 per cent in the transition probability; the accuracy is

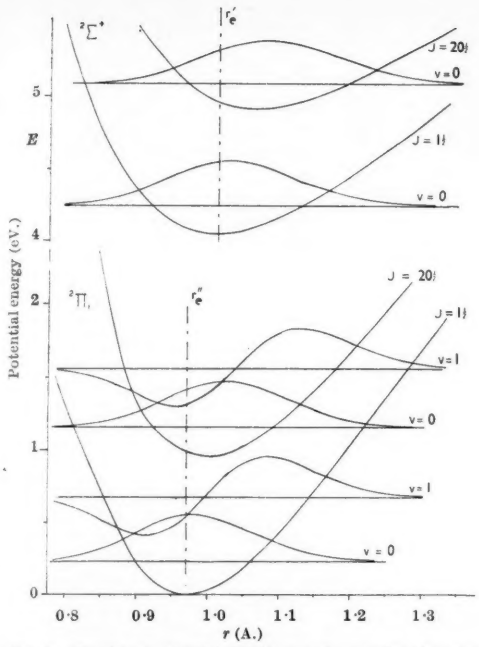

Fig. 2. Graphs of potential functions and wave functions for $A^2\Sigma$ and $X^2\Pi$ of OH

further limited by the result appearing as the difference between two relatively large quantities. The (0,0) band does not suffer from either of these defects and is therefore considerably more accurate.

We are indebted to Dr. R. C. Herman for helpful discussion.

We intend to investigate this problem in greater detail in the near future, using electronic computation to carry out the large quantities of arithmetic involved.

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[1] Gaydon, A. G., "The Spectroscopy of Flames" (Chapman and Hall, 1958).
[2] Gaydon, A. G., and Pearse, R. W. B., *Proc. Roy. Soc.*, A., **173**, 37 (1939).
[3] Schuler, K. E., *J. Chem. Phys.*, **18**, 1221 (1950).
[4] Bass, A. M., and Broida, H. P., *Nat. Bur. Stand. Circular* 541 (1953).
[5] Bass, A. M., and Broida, H. P., *J. Chem. Phys.*, **21**, 173 (1953).
[6] Herman, R. C., and Rubin, R. J., *Astrophys. J.*, **121**, 533 (1955).
[7] Rahman, A., *Physica*, **21**, 663 (1955).

Hollow-Cathode Emission of the AlO Spectrum

All emission bands previously attributed to the AlO molecule have been observed in the glow from a hollow cathode containing Al–Al_2O_3 pellets. The hollow cathode is a much more appropriate source for high-resolution studies than is the aluminium arc, and it is therefore gratifying that it may be used to excite materials as refractory as this one. Our discharge tube is quite similar to that described by Naudé and Hugo[1] except that currents as high as 2 amp. were used. It has been employed with a 150,000-line Bausch and Lomb plane grating to record the green (A—X) bands of AlO in third order at a dispersion of 0·4 A./mm. and the ultra-violet bands in second and third orders. Effective resolving powers up to 200,000 have been achieved.

Fig. 1 shows a section of the (0—0) band of the A—X system, near the head. The doublet splitting in the P-branch has been resolved down to $K = 7$. This may be compared to resolution down to about $K = 22$ in high-dispersion studies using the aluminium arc[2–4]. The averages of all measured doublet components agree with the measurements of Pomeroy[2], so that the only unique part of the present analysis of this band is the determination of the spin-doubling constants from lines of low K-values. Since there has been some disagreement about these constants, we here compare our results with those of Lagerqvist, Nilsson and Barrow[3], and of Sen[4], which are based on lines of high K-values:

	This work	Ref. 3	Ref. 4
γ'	0·019 ± 0·005 cm.$^{-1}$	0·021 ± 0·005 cm.$^{-1}$	0·030 cm.$^{-1}$
γ''	0·008 ± 0·006	0·010 ± 0·005	0·021

Fig. 2 shows a section of the more complex ultra-violet system near 3000 A. for which the hollow-cathode exposure times are about five times those for the green bands and for which only a tentative vibrational analysis has been available[5]. The present work shows that each band consists of two sub-bands, each of which contains two strong branches. Further vibrational and rotational analysis proves that the lower-state constants are those of the $^2\Sigma^+$ ground-state, observed also in the green bands. However, the upper-state ($^2\Pi_i$) vibrational constants are (in cm.$^{-1}$):

$$T_e = 33{,}174{\cdot}6, \quad \omega_e = 728{\cdot}4, \quad \omega_e x_e = 7{\cdot}5$$

rather than the following values taken from ref. 5:

$$\nu_{00} = 33{,}085, \quad \omega_0 = 845, \quad \omega_0 x_0 = 4$$

From rotational analysis of the (4—2), (1—0), (0—0) and (0—1) bands the following constants of the $B^2\Pi$ state have been obtained:

$$B_e = 0{\cdot}6027 \text{ cm.}^{-1}, \ \alpha_e = 0{\cdot}0036 \text{ cm.}^{-1} \text{ and } A_1 = -75{\cdot}78 \text{ cm.}^{-1}.$$

The observed Λ-doubling shows that the Π-state is inverted.

Continuous radiation from the cathode has hindered attempts to record the $B^2\Pi_i - A^2\Sigma^+$ bands expected at 8000 A. Earlier (Innes, K. K., and Innes, R. H. C., unpublished work), by means of a 2·5-kV.amp. arc between aluminium electrodes, these 'red' bands of AlO had been observed between 7900 A. and 8700 A. using exposure times about twenty times those necessary for the green bands from the same source. The red bands were complex and the lines were quite broad, due to the hot, comparatively high-pressure, source. Some of the few, irregularly spaced heads were degraded to the red while others were degraded to the violet. The B-value given above for the B-state is nearly equal to that of the A-state and this accounts, qualitatively, for the observed structure of the red bands, including the distribution of intensity and the paucity of sharp heads. The latter feature is probably responsible for the failure of previous attempts to identify the B—A bands at low dispersion[5,6].

The detailed work on the red bands has been resumed to determine if they can add to the information about the $B\Pi_i$ state which has been obtained from the ultra-violet bands. Detailed analysis of the

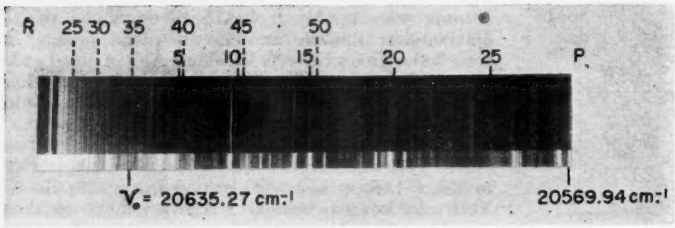

Fig. 1. 0—0 band of the $A^2\Sigma - X^2\Sigma$ system of AlO (4842 A.)

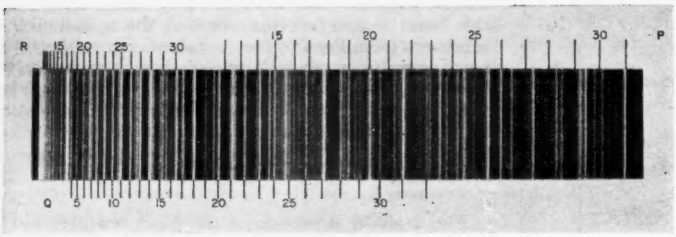

Fig. 2. 0—0 band of the $B^2\Pi_{3/2} - X^2\Sigma$ system of AlO (3028 A.)

only strong band of the remaining ultra-violet system of AlO is also in progress. A complete report of this work will be published in due course.

Support by the Naval Ordnance Laboratory of White Oak, Maryland, and by the Research Corporation is gratefully acknowledged. We are indebted to Mr. J. U. Upton of White Oak for construction of the discharge tubes used in this work. One of us (K. K. I.) wishes to thank Dr. D. V. Sickman of White Oak for helpful discussions.

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[1] Naudé, S. M., and Hugo, T. J., *Canad. J. Phys.*, **31**, 1106 (1953).
[2] Pomeroy, W. C., *Phys. Rev.*, **29**, 59 (1927).
[3] Lagerqvist, A., Nilsson, N. E. L., and Barrow, R. F., *Ark. Fys.*, **12**, 543 (1957).
[4] Sen, M. K., *Ind. J. Phys.*, **11**, 250 (1937).
[5] Coheur, F. P., and Rosen, B., *Mem. Soc. Roy. Sci., Liège*, 405 (1941).
[6] Roy, D., *Ind. J. Phys.*, **13**, 231 (1939).

Atomic Electron Affinities

Electron affinities of negative atomic ions are now being measured with increased accuracy[1]. The improvement of the experimental results makes a satisfactory theoretical approach to the problem more imperative than ever.

The best available computations of wide applicability are based on the semi-empirical method of extrapolation. This includes the oldest and most commonly employed method of quadratic extrapolation of ionization potentials first suggested by Glockler[2]. This method, *a priori*, should give the electron affinities correct in absolute value; however, many attempts over a period of years failed to produce satisfactory results. The predictions of the quadratic extrapolation are on average 0·5 eV. too low, and when this amount is added to the computed data the results still have an average error of about 0·3 eV. when compared with the best experiments available to-day. This is evident[3] from columns (1) and (2) of Table 1.

It is our feeling that the reason for the failure of the quadratic extrapolation (and related methods) lies in the sensitivity of the method to the underlying extrapolation formula. For this reason it is essential that such a formula be based on physical arguments and justification. A purely mathematical extrapolation of a table of ionization potentials has no chance of success, because the experimental data which are extrapolated here are insufficient in number as well as in accuracy. This experimental situation cannot be expected to improve greatly within the foreseeable future.

We suggest, therefore, a new extrapolation formula which has physical justification and which involves at least two parameters that admit checks by independent methods. We propose that the ionization potential be written in the form:

$$I(Z) = \alpha(Z-\sigma)^2 + \gamma + \frac{a_1}{Z-\sigma} + \frac{a_2}{(Z-\sigma)^2} + R$$

The quantity R is the remainder of the expansion in inverse powers of $(Z-\sigma)$. The corresponding series for $I(Z)$ can be justified as a fairly fast converging perturbation expansion. The five parameters α, σ, γ, a_1, and a_2 are determined from the observed ionization potentials[4] of a given isoelectronic sequence. The resultant function of Z (first four terms of $I(Z)$) is then extrapolated to the respective negative ion. The remainder, R, must be determined by comparison with experiment and is a percentage correction. If the experimental results on I were more accurate, further coefficients a_3, a_4, etc., of the expansion could be determined, and R could then be estimated theoretically. The present experimental accuracy does not permit such a procedure. In the results given, R was chosen to be 10 per cent.

As a check, the parameter α was found to be very slightly larger than $1/n^2$, where n is the principal quantum number, and σ was also found to be in satisfactory agreement with the screening parameters determined in other contexts[5].

It is to be noted that α and σ are determined by extrapolation of the isoelectronic sequence to large Z,

Table 1. Electron Affinities of Negative Atomic Ions
(All entries in eV.)

Ion	(1) Quadratic extrapolation	(2) Experiment	(3) Proposed extrapolation
B^-	− 0·089	> 0	0·82
C^-	0·83	1·13 ± 0·15	1·21
N^-	− 0·6 ± 1	< 0 ?	0·54
O^-	0·69	1·465 ± 0·005	1·47
F^-	2·93	3·62 ± 0·09	3·62
Al^-	0·50	> 0	1·19
P^-	0·57	> 0	1·33
S^-	2·07	2·07 ± 0·07	2·79
Cl^-	3·05	3·82 ± 0·06	3·84

the first term being an asymptotic value for $Z \to \infty$. In the quadratic extrapolation the first three terms of the isoelectronic sequence (lowest Z) are used for determining a quadratic in Z. Therefore, this quadratic cannot be justified as an asymptotic hydrogen-like formula. The parameters a_1 and a_2 play an essential part in the numerical value of the electron affinities.

The results are given in column (3) of Table 1 (the observed ionization potentials for the Si^- sequence are insufficient to apply our method) and are seen to agree within experimental error for all observed cases except S^-. The discrepancy in S^- may be due to incorrect experimental data on the ionization potentials of Cl I and its sequence.

A detailed report of this work will be published elsewhere.

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[1] Branscomb, Burch, Smith and Geltman, *Phys. Rev.*, **111**, 504 (1958).
[2] Glockler, G., *Phys. Rev.*, **46**, 111 (1934).
[3] Branscomb, L. M., "Advances in Electronics and Electron Physics", 43 (Academic Press, New York, 1957).
[4] Moore, C. E., "Atomic Energy Levels", Circular 467 (National Bur. Stand., Washington, D.C.).
[5] Slater, J. C., *Phys. Rev.*, **36**, 57 (1930). Kohlrausch, K. W. F., *Acta Phys. Austriaca*, **3**, 453 (1950).

Magnetic Viscosity displayed on Hysteresis Loop Traces

The earliest measurements relating the rate of change of flux to applied field under pulsed conditions were made by Sixtus and Tonks[1]. They measured the rate of propagation along a nickel wire of a wave-front of flux change and so obtained a measure of its magnetic 'viscosity'. More recently, Galt[2] has performed similar measurements involving a single domain wall in a crystal of nickel–iron ferrite. Since then, I have made measurements of magnetic viscosity in polycrystalline magnesium–manganese ferrite ('Ferroxcube' *D*1) during continuous hysteresis loop tracing, this particular ferrite exhibiting a rectangular hysteresis loop.

The method used here involved the superposition of pulsed and a.c. magnetizations. This was accomplished with negative feed-back control of the flux wave-form in the specimen, the apparatus used being fully described elsewhere[3]. It is sufficient to remark that with this apparatus over a wide range of frequency the flux wave-form corresponds almost exactly to the voltage applied to the system.

To produce the required pulse, in addition to the sine wave input normally employed, there was superposed at the same frequency a square wave with the slope of its rising and falling edges adjustable over a wide range. Thus for the duration of each edge the change of flux was rapid and constant, and throughout the remainder of the cycle it was much slower.

At the repetition frequency chosen, 330 c./s., the effect of magnetic viscosity was small, although not negligible. The rate of change in the accelerated portion of flux reversal could correspond to applied frequencies as high as 250 kc./s. or as low as 500 c./s. For these two limits, the increases in magnetizing field required were 96 and 3 per cent, respectively, of the coercive force, measured from the static loop.

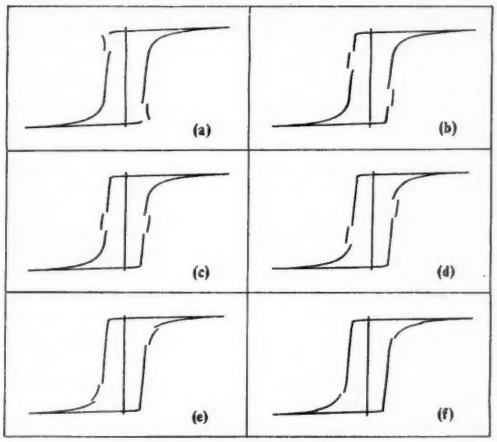

Fig. 1. Hysteresis loops with superimposed a.c. and pulsed excitations

Fig. 1 shows tracings from photographs of hysteresis loops produced by this method. The point of acceleration is shown by an outwards jump in H on the hysteresis loop, and the end of the accelerated portion by a returning jump. For the six different traces the point of acceleration occurs progressively later in the cycle. The accelerated rate of change of B was the same in each, being $1{\cdot}25 \times 10^4$ Wb./m.^{2}/sec. (with $B_m = 0{\cdot}236$ Wb./m.^{2}, $H_m =$ 500 amp. turns/m., $H_c = 77$ amp. turns/m.), but it will be seen that the initial step in H progressively decreases from one trace to the next. However, it has been found that the converse is true for the magnitude of the step when measured at the point $B = 0$. In trace (*c*) this step was 25 amp. turns/m.

The equation $dB/dt = k(H - H_0)$, which is of the same form as those obtained by Sixtus and Tonks and by Galt, was found to apply only when $(H - H_0)$ was large, of the order of 20 amp. turns/m. or more. The constant k was found to vary markedly as the point of acceleration was changed, and to a lesser extent as H_m was varied. The maximum value for k, measured when $B = 0$, was 5×10^3 Wb./m. sec. amp. turns, and its minimum was about 10^3 Wb./m. sec. amp. turns in the linear range ; but in the non-linear range when $(H - H_0)$ was small k decreased even further, approaching 10^2 Wb./m. sec. amp. turns.

The departure from linearity at the lower field strengths, which was not experienced by Galt, is apparently due to the polycrystalline nature of the material, which gives rise to a larger number of mobile domain walls. Otherwise, the results for this material, and those obtained by Galt for a single domain wall are of an identical nature.

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[1] Sixtus, K. J., and Tonks, L., *Phys. Rev.*, **37**, 930 (1931); **42**, 419 (1932).
[2] Galt, J. K., *Bell System Tech. J.*, **33**, 1023 (1954).
[3] George, R. G., *Engineering*, **182**, 333 (1956).

A Microwave Method of determining the Displacement and Velocity of a Piston in a Hypersonic Gun Tunnel

The 'hypersonic gun tunnel' is a development of the conventional shock tube, giving a comparatively long running time for aerodynamic testing purposes. Its mode of operation has been fully described[1].

A vessel containing gas at high pressure is initially separated from the main tube or gun barrel at a lower pressure by a metal diaphragm and a light piston. When the diaphragm is ruptured, the piston is driven down the barrel and a strong shock wave forms ahead of it. The shock wave is reflected several times between the end of the barrel and the piston before the latter is finally brought to rest, the slug of air ahead of it being heated and compressed in a non-isentropic manner. This region ahead of the piston can experience very high transient pressures and temperatures.

We particularly wished to study the effect of the mass and shape of the piston on the flow parameters.

The displacement and velocity of a nylon piston in the hypersonic gun tunnel at the University of Southampton has been determined by means of a microwave technique[2]. This method has been devised because it provides a large number of test stations (in this instance 120 over 10 ft.) at which displacement and velocity of the piston can be determined.

The technique regards the steel gun barrel as a resonant microwave cavity and the travelling piston as a tuning plunger moving in the cavity. A radially symmetric wave-guide mode (TM_{01}) is established in the 10-ft. long steel gun barrel of 1·25 in. internal diameter. Microwave power obtained from a reflector klystron operating in the 3-cm. commercial band is launched into the barrel by an axial probe through a wave-guide directional coupler, the latter permitting the simultaneous monitoring of the reflected or transmitted wave system with a single aerial. A crystal diode detects the reflected wave signal from the moving nylon piston. The reflexion-coefficient of the piston is increased by facing it with a shim metal disk. The time between successive standing wave minima indicates the time taken for the piston to move through a half guide wave-length. Displacements and velocities have been measured throughout the period of the piston motion.

The oscillogram (Fig. 1) shows variation of crystal diode voltage with time during a typical run; it was taken 4·0 m.sec. after the diaphragm was ruptured. Analysis indicates that the piston is increasing in velocity from 1,445 ft./sec. to 1,490 ft./sec. over a length of barrel of 3·02 in. during a time-interval of 170 μsec. This requires an acceleration of order 265,000 ft./sec.^{2}. The maximum piston velocity so far observed has been 1,700 ft./sec. If the measured signal is deliberately made asymmetric (by alteration of matching) then it is possible to observe a change of signal phase whenever the piston reverses its direction. This effect has been clearly seen during actual runs.

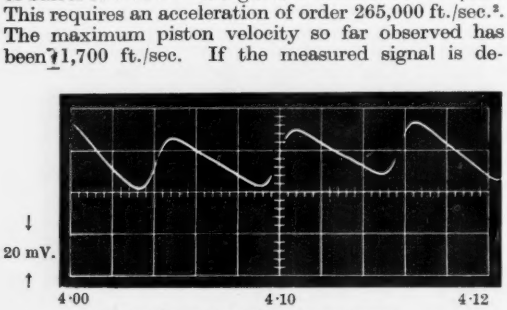

Fig. 1. Variation of crystal diode voltage with time

A raster type of cathode-ray oscillograph display is being developed which will enable the whole run to be recorded, yet have an individual line time-base sufficiently short in duration to enable accurate variations of piston velocity to be determined.

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[1] Cox, R. N., and Winter, D. F. T., Advisory Gp. Aero. Res. and Dev. Report No. 139.
[2] Bray, K. N. C., Pennelegion, L., and East, R. A., Aero. Res. Council, 20, 520.

A 'Solid-Image' Microscope

The disadvantage of the 'solid-image' microscope described by Gregory and Donaldson[1], as they point out, is that objects are seen through a relatively intense haze of background light, rather as if they were immersed in milk. There is a fairly straightforward way around this difficulty, though it entails a loss of some of the elegant simplicity of Gregory and Donaldson's instrument. During 1948–49 I devised and built at King's College a 3-dimensional scanning microscope on the same basic principle[2], which was described briefly in a report on university research in physics in 1949 [3] and exhibited at the College conversazione in that year. The slide carrier was vibrated in depth between 10 and 20 times a second with a saw-tooth motion, by means of a linear electromagnetic servo. The object, however, was scanned laterally by a flying spot on a cathode-ray tube, and the signal detected by a photomultiplier, exactly as in the 2-dimensional 'flying spot microscope' later (and apparently independently) described by Roberts and Young[4] of University College, London. The three deflecting voltages and the photomultiplier signal were supplied to a 3-dimensional projective cathode-ray tube display of the type devised for use in radar and electronic computing[5], so that a 'solid' representation of the object appeared on the screen and could be rotated at will by calibrated controls which enabled angles to be read directly.

The crucial advantage of the electronic display is that the signal can be electronically 'inverted' so as to present a negative picture showing objects in white on an otherwise dark background. In this way one could readily see single nuclear particle-tracks in emulsion (for the study of which the instrument was particularly intended) when in a 'positive' picture they were quite obscured by the bright background.

Work on the instrument was unavoidably interrupted in 1949, but my preliminary conclusion was that the astigmatism due to the inevitably poor depth-resolution must limit its usefulness to the study of fairly simple (preferably linear) structures (such as particle tracks, and perhaps nerve fibres). A severe compromise between signal-to-noise ratio, electronic resolving power, and rate of scanning is determined by the brightness of available flying-spot sources, since even ten pictures a second, with only twenty horizontal 'layers' each, require 200 frames to be scanned each second. At such rates, non-uniform scanning[6] was found to be essential to give acceptable resolution in the centre of the picture, and it seemed unlikely that for a tolerable signal-to-noise ratio, resolving power could equal that of

conventional instruments. At lower rates, of course, resolution could be as good, or even (with electronic 'sharpening') a little better.

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[1] Gregory, R. L., and Donaldson, P. E. K., *Nature*, **182**, 1434 (1958).
[2] MacKay, D. M., Brit. Prov. Pat. Spec. 844/49.
[3] Teegan, J. A., *BEAMA J.*, 378 (1949).
[4] Roberts, F., and Young, J. Z., *Proc. Inst. Elect. Eng.*, **99**, IIIA, 747 (1952).
[5] Parker, E., and Wallis, P. R., *J. Inst. Elect. Eng.*, **95**, III, 371 (1948). MacKay, D. M., *Electronic Eng.*, 248 (July) and 281 (Aug. 1949).
[6] MacKay, D. M., Brit. Pat. No. 592,372 (1947); *Electronic Eng.*, 284 (July 1950).

WE were not aware of Dr. MacKay's most interesting experiments in this field when we constructed our first prototype 'solid image' microscope, and it seems unfortunate that his work was interrupted, and not made generally available.

It should perhaps be stressed that our attempt to produce a 'solid image' is based on purely optical principles. A 'flying spot' technique requires scanning in three dimensions, rather than one only, imposing serious demands on the band-widths available with the single channel involved.

It does not seem impossible to produce brightness 'inversion' by optical means. Thus standard dark-ground illumination gives bright objects in a dark field. We are at present experimenting with various types of illumination, in an attempt to produce acceptable contrast and resolution with magnifications sufficient to reveal such structures as nuclear particle tracks in emulsion and suitably stained nerve fibres.

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Suppressed Light Emission of the Reaction Zone in Detonation

THE detonation of high explosives in water can be photographed with an open camera and a flash light as the explosive gases do not emit light. The method has been used[1] to investigate the spread of shock waves and explosive gases, and to investigate the initiation by shock waves[2]. We have found that it can be used also in certain gases such as butane and propane. The method is not suitable, on the other hand, for explosives with two levels of detonation velocity in the case of low velocity. A great part of the reaction then occurs after the reaction zone has passed and the expanding explosive gases are very luminous even in water.

In detonation with high velocity the original surface of the explosive is luminous due to the emission of light at the passage of the reaction zone. The luminosity of the surface is often very heterogeneous. Compressed TNT thus gives a distinctive pattern of small, rather sharply defined surfaces with different light intensities. Sometimes dark coherent sections appear. In transmitting detonation through water between two coaxial cylindrical charges with plane ends, the receptor charge has at its initiating end a dark band which extends right across the charge, and which increases in its axial length with the transmission distance. The detonation in the receptor charge is slightly delayed in starting, and in the meantime the shock wave from the primary charge is propagated and the dark part of the secondary charge is exposed to a high pressure.

Fig. 1 shows clearly how the light emission of the reaction zone is suppressed by an external pressure of water. The experiment was made with a spherical charge of 50 mm. diameter and two cylindrical charges of 20 mm. diameter and a length of 100 mm. in a cubical tank with a 35-cm. edge-length. The charges were of compressed TNT of density 1·53 gm./cm.^{3}. Behind the tank was placed an argon flash with a pentolite charge and a screen of paper which gave a diffuse light. All charges were initiated with detonation fuses and blasting caps, the spherical charge in the centre and the cylindrical charges at their lower end. The detonation fuses were connected to a common fuse, and their lengths were adjusted so that the argon flash was lit when the shock wave from the spherical charge met the detonation front approximately at the middle of the right cylindrical charge. It is evident from Fig. 1 that the light emission diminishes very rapidly when the reaction zone enters the pressure field of the shock wave from the spherical charge. The pressure was about 2,500 atmospheres. The left cylinder charge was initiated later, and its boundary line is therefore somewhat lower down.

To determine whether the dark part of the charges detonates in a normal manner, an experiment was made with a charge of two cylinders joined at right angles (Fig. 2). It was initiated at the lower end of the right leg so that the detonation-front met the shock wave from the spherical charge below the angle joint. The charge is dark above the intersecting line, but the detonation proceeded round the corner and on its downward course along the left leg it passed the shock wave. Below the passage line the charge again becomes luminous. In this experiment the flash was lit when the detonation front was in the dark part of the charge. The outgoing shock wave gives further confirmation that the dark part of the charge detonated in a normal manner.

Measurement of the porosity of the TNT charges has given values between 5 and 8 per cent by volume. It seems reasonable to assume that the pores of the surface layer become filled with water when the shock wave passes, and that as a consequence the luminosity weakens. It was found, however, that evacuated and water-filled charges gave a similar pattern to that of charges with air-filled pores, although the luminosity was weaker. Further, the suppression of light was about the same in cast as in compressed TNT. Part of the black-out may therefore be directly due to the pressure.

For cast pentolite with 60 per cent PETN and 40 per cent TNT the emission of light is also

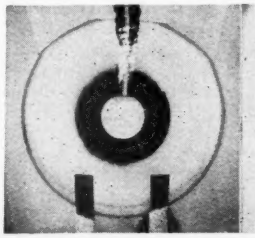

Fig. 1

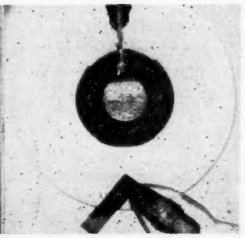

Fig. 2

diminished by a shock wave in water, but the effect is less than for TNT. Compressed PETN shows no decrease in the luminous intensity.

We wish to thank Mr. T. Edlund, manager of the Nitroglycerine Company, for permission to publish this work.

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[1] Eldridge, J. E., Fye, P. M., and Spitzer, R. W., *OSRD*, 6246 (1946).
[2] Winning, C. H., C.R. Twenty-seventh Cong. Int. Chimie Indust., Bruxelles (1954); *Proc. Roy. Soc.*, A, **246**, 288 (1958).

CHEMISTRY

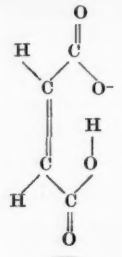
Intramolecular Hydrogen Bonding in Heterocyclic Systems

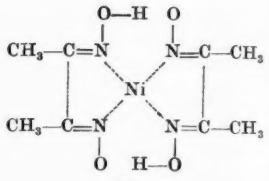
The hydrogen bond is usually described as unsymmetrical, with the hydrogen atom nearer one of the two bonding atoms, and the energy of bonding is considered as due to electrostatic and delocalization energy. The principal valency bond structures considered are I, II and III, and it has been shown[1] that when the O—O distance is 2·5 A. these three structures have the relative weights 60·3, 28·4 and 11·3. Resonance of a purely covalent character is not considered to play a part as this would require the hydrogen atom to be symmetrically placed between the two bonded atoms, and Donohue[2], by extrapolating Pauling's bond-order/bond-length relationship, has calculated that for such a bond the O—O distance could not exceed 2·4 A. However, most of the detailed studies of this problem have been concerned with intermolecular hydrogen bonds, and it is suggested here that in the cyclic systems involved in intramolecular hydrogen bonds, covalent forces play a much larger part.

—O—H · · · · O —O⁻ H⁺ · · · · O —O⁻ H—O⁺
(I) (II) (III)

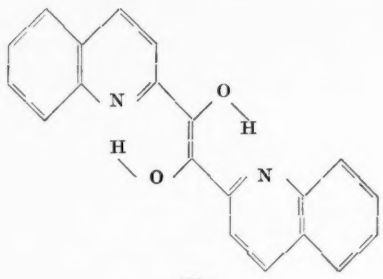
It has been pointed out[3,4] that if covalent forces played an appreciable part in hydrogen bonding, considerable alterations in the O—H stretching band in the infra-red would be expected. In the case of intermolecular hydrogen bonds the shifts in the O—H band from 3,200 cm.$^{-1}$ are usually small, and the intensity of the band is increased; but in several cases of intramolecular hydrogen bonding, the O—H band has been very drastically shifted and its intensity greatly diminished. Cardwell, Dunitz and Orgel[5] noted that the O—O distance in the hydrogen maleate ion IV should be very short (less than 2·45 A.), and that the infra-red spectrum revealed no detectable absorption from 5,000 cm.$^{-1}$ to 1,575 cm.$^{-1}$. The *bis*-dimethylglyoximinate nickel[6] or cobalt[7] complex V has an O—O distance of 2·44 A. and its O—H stretching band greatly weakened and displaced to 1,900 cm.$^{-1}$.

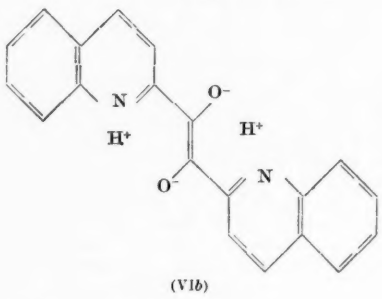
The effect of covalent resonating forms would be expected to be greater in compounds where the hydrogen bonded system could become part of an extended resonating system, and we have, therefore, examined the infra-red spectra of some heterocyclic intramolecular hydrogen bonded compounds, for example, 1,2-di-2′-quinolylethene-1,2-diol (quinaldoin), VI, deoxyquinaldoin, VII, and 1,2-di-3′-*iso*quinolylethene-1,2-diol, VIII. In these compounds the OH, NH and C=O vibrations are so modified that none of the compounds shows any absorption between 5,000 cm.$^{-1}$ and 1,625 cm.$^{-1}$.

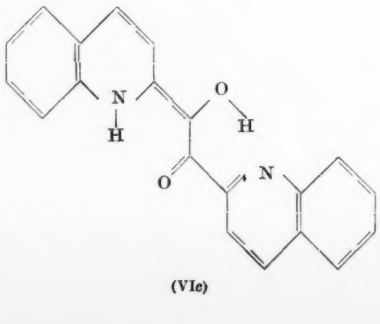

(IV)

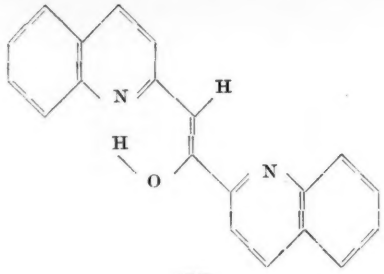

(V)

It is suggested that the lack of any absorption before 1,600 cm.$^{-1}$ in the compounds studied is due to intramolecular hydrogen bonding, stabilized by considerable resonance contributions from covalent forms (VI*a*, *c*) and facilitated by the cyclic nature of the system, that is, an essentially non-polar hydrogen bond. It has been shown[8] that the equilibrium O—H distance increases exponentially as a second electronegative atom approaches. Calculations assuming normal bond-lengths and bond-angles of 120° show that the O—N distance in these molecules lies be-

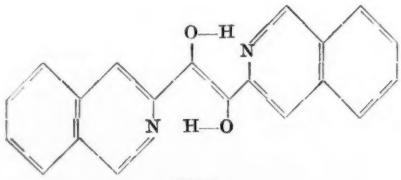

(VI*a*)


(VI*b*)


(VI*c*)



(VII)



(VIII)

tween 2·41 and 2·45 A., depending on the degree of double-bond character assumed. Taking the O—N distance to be 2·45 A. and the equilibrium O—H distance to be 1·15 A., Coulson and Danielsson's[1] method of calculation gives the relative weights of VI*a*, *b* and *c* as 52·2, 20·1 and 27·7, respectively. The covalent form VIc therefore makes a very real contribution. Due to the cyclic form of the hydrogen-bonded system electron delocalization does not involve charge transfer, and therefore the intensity of the O—H band is diminished, in contrast to the increase in intensity observed in intermolecular hydrogen bonds, where charge transfer does occur (III). This explanation could also be applied to the anomalous infra-red spectra of 2-phenacylpyridine derivatives[9], β-keto enols and β-iminoketones[10].

We therefore suggest that where resonance is possible in intramolecular hydrogen bonds in heterocyclic systems, covalent forces play a considerable part and that such systems[11] would repay further study, particularly with reference to the interatomic distances involved.

Infra-red spectra were measured in bromophthalene and perfluorkerosene pastes so there would be no possibility of a weak band being masked by the CH absorption of paraffin at 2,900 cm.$^{-1}$.

We wish to thank Dr. D. Ll. Hammick for his kind encouragement, and Mr. R. Wolley for his assistance with some of the experimental work.

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[1] Coulson, C. A., and Danielsson, U., *Ark. Fys.*, **8**, 239 (1954).
[2] Donohue, J., *J. Phys. Chem.*, **56**, 502 (1952).
[3] Davies, M., Ann. Rep. Chem. Soc., 5 (1946).
[4] Robertson, J. M., "Organic Crystals and Molecules" (Cornell, 1953).
[5] Cardwell, H. M. E., Dunitz, J. D., and Orgel, L. E., *J. Chem. Soc.*, 3740 (1953).
[6] Godycki, L. E., Rundle, R. E., Voter, R. C., and Banks, C. J., *J. Chem. Phys.*, **19**, 1205 (1951).
[7] Fujita, J., Nakahara, A., and Tsuchida, R., *J. Chem. Phys.*, **23**, 1205 (1955).
[8] Nakamoto, K., Margoshes, M., and Rundle, R. E., *J. Amer. Chem. Soc.*, **77**, 6480 (1955).
[9] Branch, R. F., *Nature*, **177**, 671 (1956).
[10] Cromwell, N. H., Miller, F. A., Johnson, A. R., Franck, R. L., and Wallace, D. J., *J. Amer. Chem. Soc.*, **71**, 3337 (1949).
[11] Eistert, B., and Munder, H., *Chem. Ber.*, **91**, 1415 (1958).

Heterogeneous Atomization of Hydrogen and Oxygen

Because of its chemical simplicity, the process of atomization of hydrogen at a surface is free from many of the ill-defined parameters which are important in more complicated heterogeneous reactions and which make their interpretation equivocal. The reaction over tungsten was discovered by Langmuir[1] and investigated quantitatively by Bryce[2] and Ivanoiskaya and Mochan[3]. The experimental arrangement employed by these authors consisted of a tungsten filament suspended in hydrogen, the wall of the reaction vessel being coated with a hydrogen-atom trapping agent so that the reaction velocity could be determined by the measurement of the rate of fall in the pressure of hydrogen. Bryce used molybdenum oxide as the hydrogen-atom trap, while Ivanoiskaya and Mochan used potassium. They found that the rate of atomization was accurately proportional to $\sqrt{P}$ in the pressure range 10^{-2}–10^{-3} mm. of mercury and the energy of activation (E) was 45 kcal./mol. or rather less.

Two atomization mechanisms are possible:

$$W - H \rightarrow W + H \qquad (1)$$

$$H_2 + W \rightarrow W - H + H \qquad (2)$$

where W denotes the tungsten surface and $W - H$ an atom of hydrogen adsorbed thereon. The assumption is made that the equilibrium $H_2 + 2W \rightleftharpoons 2W - H$ is effectively maintained throughout the reaction. Roberts and Bryce[4] applied the principle of detailed balancing to the two possibilities and showed that mechanism 1 yielded $\sqrt{P}$ kinetics only for $\theta \ll 1$, while mechanism 2 required $\theta \sim 1$ for this result, but in each case $E = \frac{1}{2}D(H_2)$. Immobility of the adsorbed layer is implicit in their discussion. Miller[5] and Laidler and his co-workers[6] have discussed the reaction from the statistical point of view. Mechanism 2 has been consistently and, as we now believe, incorrectly favoured in these treatments.

The fact that neither mechanism 1 nor 2 was capable of adequately describing the experimental results encouraged us to repeat the investigation of the kinetics of the reaction. Molybdenum oxide was employed under carefully controlled conditions as the hydrogen-atom trap, and the vacuum technique was such as to ensure clean surfaces. The $\sqrt{P}$ rate law was found to be obeyed over the pressure-range 10^{-2}–10^{-6} mm. at about 1,200° K. and the fully corrected value of E was $52{\cdot}6 \pm 1{\cdot}0$ kcal./mol. at about 1,200° K., these observations being combined in the equation:

$$\text{rate of atomization} = 18 \times 10^{24}\,(P_{H_2}\ \text{mm.})^{1/2} \exp(-52600/RT)\ \text{atoms cm.}^{-2}\ \text{sec.}^{-1}$$

These findings are compatible only with mechanism 1. An analysis of the atomization and recombination processes indicates that the adsorbed layer of hydrogen has complete two-dimensional freedom on the surface at these temperatures and further, that the ratio of atomic to molecular hydrogen desorbed from the surface has the value predicted by the equilibrium constant (K) for the reaction $H_2 \rightleftharpoons 2H$, the temperature and molecular pressure being that of the filament and the ambient gas respectively (cf. Doty[7]).

These new results have two important consequences. First, the reaction is expected to become first order with respect to the molecular hydrogen pressure at a sufficiently low value of P_{H_2}/K, and this change in rate law has been observed in the expected region.

namely, 10^{-6} mm. at 1,800° K. Secondly, the rate is independent of coverage; it is thus independent of surface structure and is determined solely by the area exposed to molecular hydrogen. A study of the atomization of hydrogen over platinum and gold supports this view.

We have also studied the atomization of oxygen over platinum using a reduced form of molybdenum oxide as the oxygen-atom trap. Again, $\sqrt{P}$ kinetics are found over an extended pressure-range and the activation energy is accurately $\frac{1}{2}D(O_2)$. Thus the present investigation, the details of which will be published later, support mechanism 1 as the process by which both hydrogen and oxygen are atomized heterogeneously.

We are grateful to Dr. B. M. W. Trapnell for initiating this investigation and to the Billingham Division of the Imperial Chemical Industries, Ltd., for financial support. We also wish to thank Dr. T. B. Grimley for much valuable discussion.

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[1] Langmuir, I., *J. Amer. Chem. Soc.*, **34**, 1310 (1912).
[2] Bryce, G., *Proc. Camb. Phil. Soc.*, **32**, 648 (1936).
[3] Ivanoiskaya, T., and Mochan, I., *J. Phys. Chem. U.S.S.R.*, **22**, 439 (1948).
[4] Roberts, J. K., and Bryce, G., *Proc. Camb. Phil. Soc.*, **32**, 653 (1936).
[5] Miller, A. R., "The Adsorption of Gases on Solids" (Camb. Univ. Press, 1949).
[6] Laidler, K. J., Glasstone, S., and Eyring, H., *J. Chem. Phys.*, **8**, 667 (1940). Laidler, K. J., *J. Phys. Coll. Chem.*, **53**, 712 (1949); **55**, 1067 (1951); *Catalysis*, **1**, 75 (1954).
[7] Doty, P. M., *J. Chem. Phys.*, **11**, 557 (1943).

Analysis of Light Hydrocarbon Gas Mixtures

It is a common analytical requirement to separate mixtures containing ethane, ethylene, propane and propylene, and, while gas chromatographic methods have been designed to separate the C_2 and C_3 gases and also the olefines from the saturated compounds, there is not, in our experience, any simple method reported for the resolution of all four gases on one column.

Olefines are cleanly separated from the saturated hydrocarbons on a column packing consisting of a saturated solution of silver nitrate in ethylene glycol supported on graded 'Celite'[1]. The C_2 gases are separated from the C_3 by a tri-*iso*butylene/'Celite' column[2]. Attempts to achieve separations by use of these two columns in series were unsuccessful (Fig. 1*a*), as were similar attempts by Bednas and Russell[2].

The technique of using a physical mixture of these two packings in one column was therefore tried. The two packings, prepared separately as before, were mixed together mechanically; this did not appear to impair their efficiency or useful life in any way. On a W-shaped column, 4 m. long × 6 mm. internal diameter, separation of all four gases was readily accomplished at room temperature and Fig. 1*b* shows a typical chromatogram obtained with this mixed packing.

The same mixture was used for each run.

Column dimensions: 4 m. × 6 mm. internal diameter; carrier gas: 0·4 l./hr. nitrogen; inlet pressure: 758 mm.; outlet pressure: 712 mm.; column and katharometer temperature: 25° C. So far as we are aware this is the first occasion on which the use of such a physically mixed packing has been reported.

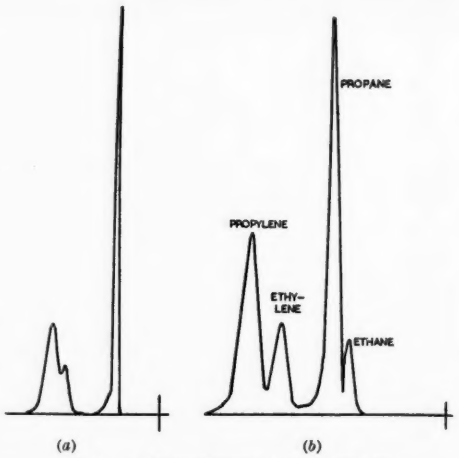

Fig. 1. *a*, Series columns; *b*, mixed packing

Further work has shown that it is also quite possible to separate *iso*butene from the four gases previously mentioned on the same column.

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[1] Bradford, B. W., Harvey, D., and Chalkley, D. E., *J. Inst. Petrol.*, **41**, 80 (1955).
[2] Bednas, M. E., and Russell, D. S., *Can. Chem. J.*, **36**, 1272 (1958).

Kinetic Isotope Effect in the Bromination of Dimethylaniline

The recent account by Shilov and Weinstein[1] of a kinetic isotope effect in the iodination of some aromatic amines prompts us to report the observation of a similar effect in the bromination of dimethylaniline.

The absence of a hydrogen isotope effect in the iodine-catalysed reaction between molecular bromine and benzene[2] shows that the C—H bond at the position of substitution is not appreciably stretched in the transition state, though the bond may have changed its hybrid character from sp^2 to sp^3, forming the Wheland intermediate[3] (I, X = Br). Other studies[4] have indicated that, in general, the degree to which the Wheland intermediate is formed in the

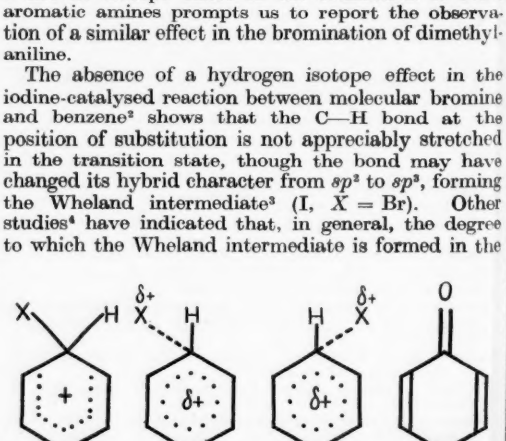

Table 1. Logarithms of the Frequency Factors (log *PZ*) for the Reaction of Benzene, Diphenyl, Naphthalene and Phenanthrene with Chlorine in Acetic Acid Solution between 15 and 30° C.

Hydrocarbon	Log *PZ*
Benzene	9
Diphenyl	7·8
Naphthalene	7·3
Phenanthrene	7·4

transition state for aromatic substitution is only partial (for example, II). If the degree of formation of the intermediate in the transition state were constant in a series of aromatic hydrocarbons for a given reagent, the frequency factor of the reaction should increase with the size of the hydrocarbon, as the positive charge would be more dispersed in the transition states of the larger aromatic molecules, and the entropy of activation due to solvation would be correspondingly smaller. However, the contrary trend has been observed[5] (Table 1), suggesting that the more reactive the aromatic hydrocarbon, the more completely formed is the Wheland intermediate in the transition state for aromatic halogenation.

With a very reactive aromatic compound it appeared possible that the passage from the Wheland intermediate to the products, that is, C—H bond-breaking, might become the rate-determining step of a halogenation reaction (for example, III), so that a kinetic hydrogen isotope effect would be observed. Prior to the work of Shilov and Weinstein[1], all kinetic isotope effects found in aromatic substitution reactions could be ascribed[6] to rate-determining C—H bond-breaking in relatively stable neutral or zwitterionic intermediates (for example, IV). To obviate such a possibility in the present study, dimethylaniline was selected as the reactive aromatic compound, and molecular bromine was chosen as the substituting reagent, since the absence of a kinetic isotope effect with this reagent had been demonstrated in the case of benzene[2]. 2,4,6-Trideuterodimethylaniline was prepared by five successive exchanges of dimethylaniline sulphate with deuterium oxide at 100° C., the extent of the exchange, as measured by infra-red spectroscopy, being more than 90 per cent. The rates of reaction of dimethylaniline and its 2,4,6-trideutero-derivative (0·005 and 0·0075 *M*) with bromine (0·003 *M*) were measured at 25 ± 0·01° C. in aqueous sulphuric acid (6·4 *M*) containing an excess of bromide ions (0·025 *M*) by Bell and Ramsden's method[7]. At both amine concentrations a kinetic isotope effect (k_H/k_D) of 1·8 was observed. With the absence of such an effect in the bromination of benzene[2], the present result suggests, like the trend of the frequency factors for the reaction of chlorine with the aromatic hydrocarbons (Table 1), that the nature of the transition state in aromatic substitution varies not only with the substituting reagent[4] but also with the aromatic molecule attacked, showing less resemblance to the reactants in the case of the more reactive aromatic compounds.

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[1] Shilov and Weinstein, *Nature*, **182**, 1300 (1958).
[2] Melander, *Arkiv Kemi, Min. Geol.*, **2**, 211 (1950).
[3] Wheland, *J. Amer. Chem. Soc.*, **64**, 900 (1942).
[4] Dewar, Mole and Warford, *J. Chem. Soc.*, 3581 (1956).
[5] Mason, *J. Chem. Soc.* (in the press).
[6] Lewis and Symons, *Quart. Rev. Chem. Soc.*, **12**, 230 (1958).
[7] Bell and Ramsden, *J. Chem. Soc.*, **161** (1958).

Exchange Reaction induced by Radiation between Diethyl Sulphate and Labelled Sulphuric Acid : a Possibly Ionic Reaction

Although ionization reactions represent one of the most important processes in the interaction of radiation with matter, relatively little interest has been shown in reactions involving ionic species with the exception of the ion-molecule reactions recently much discussed[1]. Since ionization is one of the most important processes in the interaction of radiation with matter, it is felt that a study of reactions possibly involving ionic intermediates may provide a most interesting and perhaps fruitful area of radiation research. One such system appears to be the exchange reaction induced by radiation between diethyl sulphate and radioactive sulphate ion, where any appreciable formation of diethyl sulphate-^{35}S may conceivably require $C_2H_5^+$ as an intermediate.

In our experiments, commercial diethyl sulphate was purified by vacuum distillation. Aliquots of sulphuric acid labelled with sulphur-35 (0·2–0·5 mc.) and unlabelled sulphuric acid carrier were evaporated in glass irradiation-cells and 2 ml. of the purified diethyl sulphate was added, after which the cells were evacuated and sealed off. The samples were irradiated with a cobalt-60 source (~$1·5 \times 10^6$ r./hr.), returned to the vacuum line for pressure measurements, and finally the organic phase was purified to check for any exchange reactions.

The irradiated samples were treated in the following manner. Unincorporated sulphuric acid-^{35}S and any ethyl hydrogen sulphate-^{35}S formed were extracted from the organic phase by means of carriers in the form of aqueous sulphuric acid. The extraction was continued until the sulphur-35 activity in the extractant became negligible. After the extractions, the diethyl sulphate was further purified by double distillation on the manifold and hydrolysed to the inorganic sulphate by vigorous refluxing with alcoholic sodium hydroxide. The $^{35}SO_4^=$ so obtained was precipitated with barium chloride and counted as infinitely thick samples using an end-window Geiger–Müller tube and a scaler in the standard manner[2].

Table 1. Radiation-induced Exchange between $(C_2H_5)_2SO_4$ and $H_2{}^{35}SO_4$

The samples used consisted of $2·5 \times 10^{-5}$ mole of sulphuric acid (containing 200–400 μc. of sulphur-35) in $1·54 \times 10^{-2}$ moles of diethyl sulphate (2 ml.). All samples were allowed to stand for the same length of time before processing

Irradiation dose (rads)	10[2]*	8×10^6	$2·56 \times 10^7$
Average percentage of sulphur-35 activity incorporated	0·9	3·5	6·9

* Due to the sulphur-35 beta activity

For control purposes, unirradiated samples were also processed and counted in an identical manner. The results (Table 1) show that the cobalt-60 irradiated samples undergo a considerably greater exchange than the samples which were not irradiated with the cobalt-60 source. The enhanced extent of exchange by irradiation suggests the possible presence of either (*a*) reactions involving ionized molecules of diethyl sulphate and their dissociation products, for example, the $C_2H_5^+$ ion, or (*b*) reactions involving the $C_2H_5\cdot$ radical and the $^{35}SO_4$: biradical. If ionic species were involved, the probable reactions would be :

$(C_2H_5)_2SO_4 \rightsquigarrow (C_2H_5)_2SO_4^+ + e^-$

$(C_2H_5)_2SO_4 + e^- \rightarrow (C_2H_5)_2SO_4^-$

$(C_2H_5)_2SO_4^+ + {}^{35}SO_4^= \rightarrow C_2H_5SO_4 + C_2H_5{}^{35}SO_4^-$

$C_2H_5SO_4 \longrightarrow$ dissociation products

$C_2H_5{}^{35}SO_4^- + (C_2H_5)_2SO_4^+ \longrightarrow (C_2H_5)_2{}^{35}SO_4 + C_2H_5SO_4$

$C_2H_5^+ + {}^{35}SO_4^= \rightarrow C_2H_5{}^{35}SO_4^- \xrightarrow{+C_2H_5^+} (C_2H_5)_2{}^{35}SO_4$

In spite of the rather low concentration of the ionic species involved (about 10^{17} sulphuric acid molecules or ions versus about 10^{22} diethyl sulphate molecules per ml.) the exchange reaction appears to be a relatively efficient process. Possible applications of these reactions may be (*a*) tagging of various sulphur compounds as well as substances which cannot be conveniently tagged by other techniques and (*b*) studying of the behaviour of ionic species produced by radiation in a liquid system.

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[1] See, for example, Stevenson, D. P., *J. Phys. Chem.*, **61**, 1453 (1957).
[2] Friedlander, G., and Kennedy, J., "Nuclear and Radiochemistry", 278 (John Wiley, New York, 1955).

Peak Dimensions in Gas Chromatography

Whatmough's observations[1] can be explained if the absorption isotherms of his packing material are non-linear and if one takes account of variations of flow velocity in the column[2].

At a point where the vapour concentration is c let the total quantity of vapour, including that absorbed, be q per unit volume of free space. If the flow velocity is u, then:

$$\frac{dq}{dt} - \frac{dc}{dt} = -\frac{du}{dx} \quad (1)$$

If local equilibrium is attained instantaneously and longitudinal diffusion is negligible, then:

$$\frac{d(uc)}{dc}\left(1 - \frac{dc}{dq}\right) = \frac{du}{dc} \quad (2)$$

If u_0 is the velocity in regions containing pure carrier gas, then since q is a function of c, it is clear from (2) that u/u_0 is also a function of c. Take the case of a packing in which:

$$q = c + \frac{\sigma c}{1 + \alpha c} \quad (3)$$

If the column is being saturated by passing in a mixture of concentration c, then the quantity of gas entering per unit volume saturated is:

$$1 + \frac{\sigma}{1 + \alpha c} \quad (4)$$

and the quantity of carrier gas leaving the exit is:

$$1 + \frac{\sigma(1 - c)}{(1 + \alpha c)} \quad (5)$$

This gives:

$$\frac{u}{u_0} = \frac{1 + \sigma + \alpha c}{1 + \sigma + \alpha c - \sigma c} \quad (6)$$

The rate of advance of the front is:

$$u_0(1 + \alpha c)/(1 + \sigma + \alpha c - \sigma c) \quad (7)$$

At small concentrations the rate of advance is $u_0/(1 + \sigma)$; let $X = u_0 t/(1 + \sigma)$ and let time be measured from the instant that the injection of a sample is complete. If q is assumed to be a function of x/X in the regions where it is neither zero nor constant, then:

$$\frac{\partial q}{\partial X} = -\frac{x}{X} \cdot \frac{\partial q}{\partial x} = -\frac{1 + \sigma}{u_0} \cdot \frac{\partial (uc)}{\partial x}$$

$$\text{whence } \frac{x}{X} = (1 + \sigma)\frac{d}{dc}\left(\frac{u}{u_0}c\right)\Big/\frac{dq}{dc} \quad (8)$$

c is zero when $x < X$ and beyond this point increases nearly linearly at a rate inversely proportional to X. This continues until $c = c_0$, the sample concentration, or until the front is reached at some lower concentration c_m. The front remains sharp. If L is the length of the column, then the total quantity of vapour leaving the exit per unit free cross-section is given by:

$$Q = \int uc\,dt = (1 + \sigma)\int_0^{c_m} \frac{u}{u_0} c \cdot \frac{d(L - X)}{dc}\,dc \quad (9)$$

From (3) $\dfrac{dq}{dc} = 1 + \dfrac{\sigma}{(1 + \alpha c)^2}$ and from (6) and (8) it is possible to evaluate (9).

If L is long enough to make c_m less than c_0 then:

$$\frac{1}{c_m} - \frac{\sigma\alpha c_m}{2(1 + \sigma)^2} + \ldots = \left\{\frac{L\sigma(1 + \alpha)}{Q}\right\}^{1/2} - \alpha \quad (10)$$

In practical cases the term in c_m will be negligible.

The quantity of vapour deduced from the area of a recorder peak is given by:

$$Q' = u_0 \int c\,dt \quad (11)$$

To a sufficient approximation:

$$Q' = Q\left(1 - \frac{2}{3} \cdot \frac{\sigma}{1 + \sigma} c_m\right) \quad (12)$$

Taking the ratio of peak area to peak height as a measure of peak width:

$$\frac{Q'}{c_m} = \left\{QL\sigma(1 + \alpha)\right\}^{1/2} - Q\left(\alpha + \frac{2}{3} \cdot \frac{\sigma}{1 + \sigma}\right) \quad (13)$$

This is a maximum when:

$$\left\{\frac{L\sigma(1 + \alpha)}{Q}\right\}^{1/2} = 2\alpha + \frac{4}{3} \cdot \frac{\sigma}{1 + \sigma} \quad (14)$$

The value of dc_m/dQ is a minimum when:

$$\left\{\frac{L\sigma(1 + \alpha)}{Q}\right\}^{1/2} = 3\alpha \quad (15)$$

Whatmough uses an arbitrary concentration scale so that quantitative comparisons are impossible, but for values of c_0 exceeding 0·2 his peak maxima are well represented by:

$$\frac{K}{c_m} = \left(\frac{15}{c_0}\right)^{1/2} - 1 \quad (16)$$

Diffusion has little influence on peak width if Q is large; but if it is small, diffusion predominates and gives an almost Gaussian distribution with a maxi-

mum proportional to Q; this accounts for the linear start of his peak height curve.

From (16) the minimum value of dc_m/dc_0 should occur when $c_0 = 5/3$ and the maximum peak width at a not very different value; this accounts for the straightening of the peak height curve and the slow change of width at high values of c_0.

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[1] Whatmough, P., *Nature*, **182**, 863 (1958).
[2] Bosanquet, C. H., and Morgan, G. O., "Vapour Phase Chromatography", edit. by Desty, D. H. (Butterworths, London, 1956).

GEOLOGY and MINERALOGY

Structural Control of Polymorphism in Micas

The extensive polymorphism shown to exist among the mica minerals by Hendricks and Jefferson[1] has been confirmed by a number of workers in more recent years[2,3]. Polymorphism similarly has been clearly demonstrated for other layer lattice silicates, for example, for the chlorites by Brindley, Oughton and Robinson[4].

It is well known that micaceous minerals can form polymorphs principally because the surfaces of the individual silicate layers are composed of oxygen atoms arranged in hexagonal networks. Thus the successive layers can be superimposed or stacked in a number of different ways, in each of which the two hexagonal layer surfaces pack together identically, oxygen to oxygen; but these different ways of layer stacking can give rise to different symmetries and unit cells in the total structure. The successive layers may be regarded as being related to each other by regular rotations between layers, this being geometrically equivalent to regular translations of successive layers along either the a-axis or the b-axis or both. (The concept of rotations between layers is geometrically simpler, but that of translations may be more acceptable physically.)

Smith and Yoder[5] have developed a theory based on these ideas to predict all the possible polymorphs of micas which may occur. They have shown that there are six simple ways of stacking mica layers in an ordered manner, these being based on "inter-layer stacking angles" as follows: $1M$ (one-layer monoclinic) on 0° stacking angles, $2M_1$ on alternating 120° and 240° angles, $3T$ (three-layer trigonal) on 120°, $2O$ (two-layer orthorhombic) on 180°, $2M_2$ on alternating 60° and 300°, and $6H$ (six-layer hexagonal) on 60° angles. While Smith and Yoder discussed the possible factors governing the growth of various polymorphs (including forces due to distortions of the hexagonal oxygen networks) it was not possible to explain, on the evidence then available, their observed relative abundance. It was noted, however, that only the $1M$, $2M_1$, and $3T$ polymorphs are common in Nature, and that $2O$ and $6H$ specimens had not been found at all. Lepidolite specimens crystallizing with the $2M_2$ structure have been described by Levinson[2] and others.

The rarity or non-occurrence of the $2O$, $2M_2$ and $6H$ mica polymorphs appears to me to be explained fairly satisfactorily by the observed departures of layer-lattice silicates from their ideal structures, as reported in several recent analyses (of vermiculite[6], of dickite[7] and of amesite[8]). In each of these the oxygen network is distorted from a hexagonal array to one in which the oxygen atoms are arranged on two interpenetrating triangles of different sizes. For vermiculite these are two isosceles triangles with the equal sides 4·35 and 4·84 A. respectively; but it is to be noted that both triangles are very nearly equilateral. Mathieson and Walker point out that the distortion can be viewed as due to a rotation of triads of oxygen of about $5\frac{1}{2}°$. I am at present re-investigating the $2M_1$ muscovite structure; and while the atomic parameters are not finally fixed it is clear that a similar—though probably greater—distortion of the oxygen network exists in this mica.

The net effect of such distortions is to lower the symmetry of the surface layer from hexagonal to approximately, though not precisely, trigonal. Those polymorphs which result from interlayer stacking angles of 0°, 120° or 240° may therefore occur fairly readily, though their relative abundance may depend on how nearly trigonal the oxygen network is in a given mineral. But those polymorphs based on angles of 60°, 180° or 300° may be expected to occur infrequently (and only as fine-grained specimens), since considerable adjustments of oxygen positions on each layer face would be necessary.

The above argument seems to be supported by the fact that the $2M_2$ mica structure has only been observed for lepidolites. Smith and Yoder[5] pointed out the controlling effect of the linked array of SiO_4 and AlO_4 tetrahedra on the dimensions of the micas; and Newnham and Brindley[7] have attributed the rotations of these tetrahedra in dickite to the misfit of the 'oversize' tetrahedral layer on to the smaller octahedral layer. The lepidolites have less tetrahedral aluminium-for-silicon substitution than other micas, and this layer will thus have dimensions more nearly equal to the (smaller) octahedral layer.

It may be expected that there will therefore be less strain in lepidolites due to tetrahedral–octahedral misfit. This suggests that the oxygen configuration will show a smaller degree of distortion from the ideal hexagonal symmetry, thus allowing a polymorph based on 60° rotations (such as $2M_2$) to occur.

This hypothesis can, of course, only be tested satisfactorily by an accurate analysis of the $2M_2$ lepidolite structure.

For micas other than lepidolites and brittle micas the tetrahedral layer has cation composition $Si_{3/4}Al_{1/4}$, and this network, according to Smith and Yoder[5], should have b-dimensions of $9{\cdot}30 \pm 0{\cdot}06$ A. There will be little distortion of the oxygen hexagons in those micas having a b-axis close to this value (for example, phlogopites and some biotites). If the above argument is valid then the $2O$, $2M_2$ and $6H$ polymorphs may occur among these micas.

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[1] Hendricks, S. B., and Jefferson, M. E., *Amer. Min.*, **24**, 729 (1939).
[2] Levinson, A. A., *Amer. Min.*, **38**, 88 (1953); **40**, 41 (1955).
[3] Yoder, H. S., and Eugster, H. P., *Geochim. and Cosmochim. Acta*, **8**, 225 (1955).
[4] Brindley, G. W., Oughton, Beryl M., and Robinson, K., *Acta Cryst.*, **3**, 408 (1956).
[5] Smith, J. V., and Yoder, H. S., *Min. Mag.*, **31**, 209 (1956).
[6] Mathieson, A. L., and Walker, G. F., *Amer. Min.*, **94**, 231 (1954).
[7] Newnham, R. E., and Brindley, G. W., *Acta Cryst.*, **9**, 759 (1956).
[8] Steinfink, Hugo, and Brunton, George, *Acta Cryst.* **9**, 487 (1956).

Some Palæomagnetic Investigations on Chinese Rocks

Previous palæomagnetic investigations[1] on European and North American rocks agree in suggesting that those areas were in such a position that the pole appeared to lie on or near the Chinese mainland from Upper Palæozoic to Mesozoic times. If the geology of China is examined for those same periods, the climate indicated is more equatorial than polar[2]. These two apparently contradictory facts make the palæomagnetic study of Chinese rocks particularly interesting, and account for the publication of the results of the first collection from China despite the small number of samples.

The collection was comprised of some eleven samples, of which eight were of the Tertiary Kansu Series collected at three sites in Kansu, while the remaining three were of red Middle Silurian siltstones from the southern part of Yumen, Kansu province. The Tertiary rocks unfortunately were magnetically unstable, being characterized by low intensities of magnetization and scattered results. The measurements on the Silurian rocks yielded a more consistent pattern (Fig. 1). The mean declination was N. 66·4° W., mean inclination + 55·3°, with a circle of confidence of 8·5° calculated from 17 measured disks. The mean intensity of magnetization was $8{\cdot}8 \pm 3{\cdot}8 \times 10^{-6}$ e.m.u./cm.³.

The position of the ancient pole was 168° W. 49° S. or 12° E. 49° N., which compares with the Silurian pole from North America of 138° E. 19° N. and by extrapolation an estimated position of a European pole in 165° E. 22° N. If this Chinese result is confirmed by further collections, the following implication, first suggested by Nairn[3] as a result of comparing Permian palæoclimatic and palæomagnetic data, would seem to be valid, namely, that differential movement occurred between Europe and North America and Eastern Asia. This is a significant addition to the Continental Drift theory, for it implies that at the time when Gondwanaland was a single unit, China at least was not part of the Laurasian continent. Further investigation of this possibility is at present in progress.

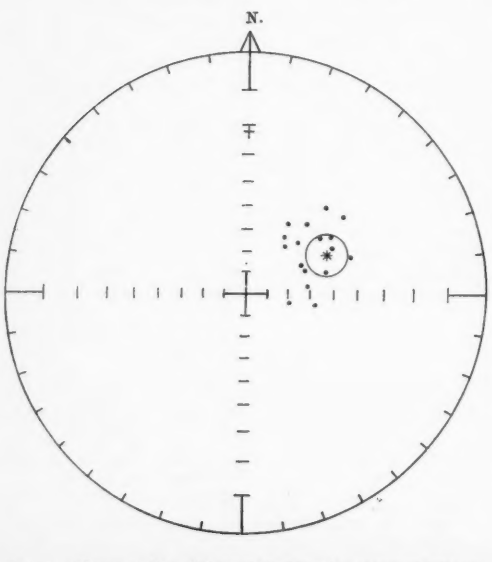

Fig. 1. Stereographic plot of palæomagnetic measurements on middle Silurian rocks from Kansu province. ●, N. pole pointing down; +, theoretical dipole field at the site; *, mean direction of magnetization enclosed within the circle of confidence

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[1] Creer, K. M., Irving, E., and Runcorn, S. K., *Phil. Trans. Roy. Soc.*, **A, 250**, 144 (1957).
[2] Lee, J. S., "The Geology of China" (Murby, London, 1939).
[3] Nairn, A. E. M., *Bull. Soc. Géol. France*, **7**, 721 (1957).

Chemical Composition of Tektites

In a recent communication[1], Prof. H. Urey makes the following statement: "Tektites have chemical compositions remarkably similar to those of the more acid sedimentary rocks. This is true for the major and minor constituents. (I have been privileged to see analyses as yet unpublished on these minor constituents.) Such a chemical composition is not produced by any other naturally occurring chemical processes that we know of, except perhaps in very rare and special circumstances". Similar statements have appeared in other papers dealing with tektites, and give the impression that their compositions can be explained only by the fusion of sedimentary rocks.

One may reasonably ask which are these "more acid sedimentary rocks" to which Prof. Urey refers. I do not know any publication in which analyses of tektites are directly compared with those of sedimentary rocks. The most comprehensive compilation of tektite analyses is that of Barnes[2]. In discussing these analyses Barnes applies certain criteria for suspecting a sedimentary origin from the chemical composition (excess of aluminium oxide, potassium oxide > sodium oxide combined with magnesium oxide > calcium oxide and very great excess of silicon dioxide). On the basis of these criteria he concluded that: "There is a strong suggestion that Darwin glass, bediasites, and possibly the moldavites and Ivory Coast tektites are fused sediments. The indochinites, billitonites, and australites on this basis are most closely allied to the igneous rocks".

Nevertheless, a rapid survey of published analyses shows the existence of igneous rocks of comparable composition to each of the principal tektite types (Table 1). The igneous rock analyses were selected from Washington's compilation[3], the tektite analyses from Barnes's monograph[2]. An analysis of each tektite type is paired with the analysis of an igneous rock; the correlation within each pair is on the whole very close.

It is incumbent on those claiming near identity of composition between tektites and sedimentary rocks to show that an equally close correlation is possible between these tektite analyses and analyses of individual sedimentary rocks. Even if such a correlation can be established, it should be clear from Table 1 that material with the chemical composition of tektites can be produced by more than one naturally occurring chemical process. To argue that the chemical composition of tektites indicates that they

Table 1

	A1	*A2*	*B1*	*B2*	*C1*	*C2*	*D1*	*D2*	*E1*	*E2*	*F1*	*F2*	*G1*	*G2*
SiO_2	97·58	96·16	86·34	81·25	80·52	80·55	77·76	76·71	72·39	72·40	72·40	71·62	68·60	68·90
Al_2O_3	1·54	1·31	7·82	9·03	9·44	9·87	13·30	12·81	13·12	12·56	12·68	12·81	15·80	13·39
Fe_2O_3	0·11	0·02	0·63	0·63	—	2·13	0·37	0·80	0·42	none	0·23	1·64	0·18	3·45
FeO	0·23	0·09	2·08	0·40	1·98	—	3·36	1·72	4·48	4·03	3·59	1·76	6·46	1·39
MgO	trace	0·03	0·92	2·48	1·73	0·81	1·19	0·40	1·87	1·87	2·34	1·08	2·88	4·10
CaO	0·38	trace	0·05	trace	1·84	2·21	0·04	1·90	3·17	2·09	2·75	3·14	1·40	3·31
Na_2O	0·34	0·56	0·15	0·25	0·52	0·42	1·41	1·76	1·54	2·14	1·68	2·73	2·35	2·07
K_2O	none	0·30	0·87	1·82	3·15	2·43	1·97	1·48	1·92	1·95	3·16	3·02	1·92	2·88
H_2O^+	0·10	0·51	0·43	2·81	0·11	1·06	0·02	0·77	0·11	1·25	0·43	1·93	—	0·90
H_2O^-	—	0·08	0·03	1·09	0·05	—		0·33	0·02	0·15	—	—	—	—
TiO_2	0·21	—	0·52	0·08	0·72	—	0·76	0·14	0·76	0·77	0·74	—	0·80	—
MnO	trace	—	nil	trace	0·09	—	0·01	0·27	0·05	0·50	0·06	—	0·06	—
	100·49	99·06	99·95	100·24	100·36	99·48	100·19	99·66	99·91	99·88	100·20	99·73	100·45	100·59

A1, Libyan Desert glass (Univ. Texas Pub. 3945, anal. 65).
A2, Granite (marginal variety), Eskdale, England (U.S. Geol. Surv. Prof. Paper 99, 51).
B1, Darwin glass (also ZrO_2, 0·11) (Univ. Texas Pub. 3945, anal. 1).
B2, Metarhyolite, Shasta Co., Calif. (also S, 0·35; BaO, 0·05) (U.S. Geol. Surv. Prof. Paper 99, 51).
C1, Moldavite (Univ. Texas Pub. 3945, anal. 12).
C2, Felsite, Co. Waterford, Ireland (U.S. Geol. Surv. Prof. Paper 99, 53).
D1, Bediasite (Univ. Texas Pub. 3945, anal. 16).
D2, Granite, Settsu, Japan (also P_2O_5, 0·48; ZrO_2, 0·03; S, 0·06) (U.S. Geol. Surv. Prof. Paper 99, 53).
E1, Australite (also NiO, 0·06) (Univ. Texas Pub. 3945, anal. 56).
E2, Granite, Reefton, New Zealand (also P_2O_5, 0·09; SO_3, 0·08) (U.S. Geol. Surv. Prof. Paper 99, 331).
F1, Indochinite (also P_2O_5, 0·14) (Univ. Texas Pub. 3945, anal. 40).
F2, Granite, Styria, Austria (U.S. Geol. Surv. Prof. Paper 99, 103).
G1, Ivory Coast tektite (Univ. Texas Pub. 3945, anal. 63).
G2, Quartz diorite, Corsica (also P_2O_5, 0·20) (U.S. Geol. Surv. Prof. Paper 99, 331).

must have originated by the fusion of sedimentary rocks is unwarranted.

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[1] Urey, H. C., *Nature*, **182**, 1078 (1958).
[2] Barnes, V. E., *Univ. Texas Pub.*, 3945 (1940).
[3] Washington, H. S., U.S. Geol. Surv. Prof. Paper 99 (1917).

Glaciation in the Jammu Hills

MUCH evidence of the last or Pleistocene Ice Age has been observed in various parts of the Central and the Lesser Himalayas. Lieut.-Col. J. L. Grinlinton has referred to the shape of polished and striated or grooved rock surfaces in the Liddar and Sind Valleys of the Kashmir Himalayas[1]. Many terminal moraines have also been noticed on the southern flank of the Pirpanjal at altitudes of somewhat less than 8,900 ft.; but no traces of the Pleistocene glaciation have been so far discovered anywhere in the Jammu Hills south of the Pirpanjal.

My colleague, Mr. T. R. Bhatia, and I recently visited Tringla, close to Batote hill station 78 miles from Jammu. Batote is situated at lat. 33·7° and long. 75·20° at an altitude about 5,000 ft. above sea-level. This hill station and the entire country from Udhampur to Peera and leading to Srinagar, Murree and beyond in West Pakistan, to Teetwal in the north-west and for a considerable distance eastwards is covered by the rocks belonging to the Murree series, of Oligocene and Lower Miocene age.

Our attention was attracted in this series by a few outcrops of the compact and hard sandstone which showed an unusual degree of smoothness. A closer examination of these outcrops revealed a number of grooves, roughly parallel to one another, running in a north–south direction and 5–9 in. long. Evidently these were glacial striæ on the polished sandstone dipping roughly southwards at an angle of about 40°, furnishing convincing proofs of their having been produced by glacial action during the Pleistocene Ice Age. The grooves possessed a virtually original freshness and appeared to have been rubbed off from the neighbouring polished surface. In one sandstone projection a fairly large cut with polished sides was seen. This must have been carved by the silt-charged water when the ice was in the process of melting. Further investigation near the same spot showed a number of large boulders with polished and grooved surfaces. On one of them the grooves were intact, but the polish had completely gone. Similar observations were made about 1 mile to the east towards the Chakou Nala.

In our opinion, the Patni Top area south of Batote, altitude 7,000 ft., served as the gathering ground for the snow and ice during the Pleistocene times and from this snowfield one or more glaciers descended northwards towards Batote. The entire Patni Top area has at present the topography of a big cirque now breached by a couple of small streams.

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[1] Geol. Surv. Ind., Mem. **49**, Pt. 2.

Niobium–Zirconium–Thorium–Uranium and Rare-Earth Minerals from the Pegmatites of South Harris, Outer Hebrides

DURING a recent examination of some of the pegmatites in the Lewisian rocks of South Harris a suite of rare minerals was found which may stimulate further research into the numerous, but somewhat neglected, pegmatite occurrences in other parts of the Lewisian of north-west Scotland.

References to the South Harris pegmatites have been made from time to time[1–4], and Holmes, Shillibeer and Wilson[5] estimated the age of the potash-felspars from the Chiapaval and Roneval pegmatites by the potassium–argon method and found them to be 1,110 ± 70 million years, and 1,140 ± 70 million years, respectively.

In the earlier part of the Second World War, the Chiapaval pegmatite near Northton and the Sletteval pegmatites east of Roneval were opened out and quarried for potash-felspar on a considerable scale. These large quarries attracted our interest, and a search for rare minerals was made.

The Chiapaval pegmatite vein, which stretches for a mile, and in places is up to 80 ft. thick, consists of

microcline, albite and quartz, with a subordinate amount of muscovite as the major mica constituent. Of the minor minerals, topaz, beryl, black-tourmaline and garnet have been previously recorded[1,4]; the latter mineral seems to be quite abundant locally and was found to contain some 20 per cent of manganese monoxide. In addition, the following minerals have been found: columbite (approximately 60 per cent of niobium pentoxide), thorite, uraninite, kasolite (a hydrated uranium-lead silicate), a mineral with an X-ray diffraction pattern almost identical with kasolite, but predominantly a thorium-lead silicate, betafite, zircon, monazite, allanite, and gahnite (a zinc-spinel).

No zoning on a large scale is apparent in the Chiapaval pegmatite: on a small scale, however, microcline–albite–quartz zoning does occur. The rare minerals are not confined to any particular zone or paragenesis, and columbite, for example, was observed in association with microcline, albite, muscovite and quartz, and even at times enclosed in the manganese garnet. The association garnet–gahnite–columbite is quite common.

The main Sletteval pegmatite quarries, east of Roneval, were examined in some detail; but apart from apatite no unusual minerals were observed.

A pegmatite north-east of Sletteval, near Loch a' Sgurr, contained numerous magnetite aggregates, associated with a greenish-yellow mica, which were found to be quite radioactive. Laboratory investigation showed that this pegmatite contained uraninite, thorite, monazite, uranophane and epidote, together with metamict zircon and allanite, and minor spessartine and pyrites. Under the binocular microscope, all these minerals can be seen closely associated with the magnetite.

The pegmatites of the area fall into two major groups: (*a*) those with muscovite as the dominant mica; (*b*) those containing biotite mica, magnetite and only minor muscovite, which generally show more radioactivity than the former.

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[1] Heddle, M. F., "The Mineralogy of Scotland" (1901).
[2] Jehu, T. J., and Craig, R. M., *Trans. Roy. Soc. Edin.*, **55**, 41 (1927).
[3] Davidson, C. F., *Trans. Roy. Soc. Edin.*, **61**, 108 (1942).
[4] Robertson, T., Geological Survey of Great Britain, War-time Pamphlet No. 44 (1945).
[5] Holmes, A., Shillibeer, H. A., and Wilson, J. T., *Nature*, **176**, 390 (1955).

BIOCHEMISTRY and PHYSIOLOGY

Presence of Griseofulvin in Hair of Guinea Pigs after Oral Administration

Gentles[1] has found that oral administration of griseofulvin to guinea pigs previously infected with either *Microsporum canis* or *Trichophyton mentagrophytes* arrests the progress of the fungal disease and prevents the highly inflammatory reaction normally encountered in untreated animals. Histological examination showed that most of the hair follicles and most of the lower portions of hair-shafts were free from dermatophytes after a few oral doses of the antibiotic. The hyphal tips of the fungi were sometimes malformed and in that way reminiscent of the effect of griseofulvin on other susceptible fungi.

These findings can be explained by postulating that griseofulvin is deposited in the keratinous layer of the epidermis and penetrates into the hair follicle, where it is somehow incorporated into the newly formed keratin of emerging hair-shafts. The latter should thus contain a band of resistant keratin from which it might be possible to recover griseofulvin.

To test this theory, bulked hair from several untreated guinea pigs and from animals that had received 23 consecutive daily oral doses of 30–40 mgm./kgm. were extracted and the purified extracts were subjected to bio-assay against *Alternaria solani*, using a modification (Napier, E. J., and Rhodes, A., personal communication) of the *Botrytis allii* hyphal curling assay[2]. The bio-assays were carried out by Mrs. E. J. Napier, of Glaxo Laboratories Ltd.

Since the bio-assay is affected by the presence of some contaminants, a fairly elaborate purification procedure was used. The animals were kept in individual cages with wire grid bases, to avoid contamination with griseofulvin from urine or fæces, and were closely clipped before treatment, to ensure a high concentration of griseofulvin in the hair. At the end of the treatment, 7·5-gm. portions of hair from treated and untreated animals were washed by stirring for half an hour with 450 ml. water and then similarly stirred and filtered three more times. The first three filtrates (*a*) were combined, (*b*) the fourth was kept separate. The hair was then extracted by refluxing four times for half an hour with 250-ml. portions of methanol. The first three filtrates from these extracts (*c*) were combined and (*d*) the fourth was kept separate. The aqueous filtrates (*a* and *b*) were extracted separately with half-volumes of light petroleum (60°–80° C.). This removes undesirable lipoid matter, but extracts some griseofulvin also, which was recovered by re-extracting the petroleum layers with equal volumes of 50 per cent aqueous methanol. After the methanol had been removed from these phases by distillation under reduced pressure, the aqueous residues were bulked with the corresponding main aqueous fractions, each of which was then extracted with benzene (3 × quarter-volumes). The two benzene extracts were dried over sodium sulphate, concentrated to small bulk under reduced pressure and passed through alumina columns (3*g*, 'Woelm acidic'). Development with benzene (about 200 ml.) having removed further impurities, the griseofulvin was eluted with 1 per cent ethanol in benzene. The eluates were evaporated to dryness under reduced pressure and were then ready for bio-assay.

The two methanolic filtrates (*c* and *d*) were extracted with half-volumes of light petroleum, which was discarded. The methanol solutions were concentrated to small bulk with the addition of water, distillation being continued until all methanol had been removed. The aqueous solutions were extracted with benzene and the benzene extracts processed further, as described above. The results of the eight bio-assays are shown in Table 1.

From 1 gm. hair of the treated animals, between 5 and 6 μgm. griseofulvin were obtained, about half

Table 1. Griseofulvin Content of Guinea Pig Hair

Fraction	Total griseofulvin (μgm.) in 7·5 gm. hair: Control	Treated
a	0	21
b	0	0
c	0	20
d	0	0·8

of it being extractable by cold water. It is not at present clear whether perhaps this portion was excreted through the skin and only adhered to the hair, the other half having been deposited in the hair keratin. Whatever the exact mechanism, it seems fairly certain that the eradication of dermatophytic infections by griseofulvin is due to its incorporation somehow in keratinous tissues.

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[1] Gentles, J. C., *Nature*, **182**, 476 (1958).
[2] Brian, P. W., *Ann. Bot.* (N.S.), **13**, 59 (1949).

Effects of Deficiency of Pantothenic Acid on Oxygen Poisoning in the Rat

It has been known for many years[1] that a close connexion exists between pantothenic acid and the suprarenal glands, atrophy of which may result from a deficiency of pantothenic acid. More recently, Hurley and Morgan[2], arguing that animals in the final stages of pantothenic acid deficiency should behave as though adrenalectomized, showed that rats on such a diet were less resistant to the stress of anoxia than were normal controls.

It has, however, been shown that when the 'stress' is exposure to pure oxygen under high pressure, adrenalectomized rats fare better than do normal animals[3–5]. I found[6] that the variability in the time of appearance of nervous system effects in oxygen poisoning was very great in adrenalectomized rats and could not be correlated with the presence of small amounts of residual cortical tissue. Since it seemed reasonable to assume that a dietary deficiency would affect all susceptible tissue, irrespective of its site in the body, it followed that a pantothenic acid deficiency might well dispose of aberrant cortical tissue in a way that operation could never do. If such deficient animals were at least as resistant as operated animals and showed less variability of response, the result would tend to confirm the hypothesis that in operated animals the variability was in fact due to aberrant cortical tissue.

A series of experiments was carried out to test the effects of exposure to pure oxygen under a pressure of 6 atm. on rats reared on a pantothenic acid-deficient diet. Eight litters of eight rats, four of each sex, were used. The basic diet was that already described by me[7]. Appropriate vitamin supplements other than pantothenic acid were added to it, and it was fed to the mothers from 12 days before weaning. On weaning, the young rats were divided into 4 groups as follows: *A*, rats fed the deficient diet *ad lib.*; *B*, rats given the basic diet with vitamin supplements, including pantothenic acid (that is, the control diet), and pair-fed within litters with those of *A*; *C*, rats from which both adrenals were removed four days before exposure to oxygen and fed the control diet *ad lib.*; *D*, rats fed the control diet *ad lib.*

At the age of approximately 8 weeks the rats were exposed to oxygen under 6 atm. in a way already described[6]. Four male and two female rats in group *A* died before exposure to oxygen.

The mean times to the onset of severe poisoning, with standard errors, were, for the four groups, as follows: *A*, 49·75 ± 4·46 min.; *B*, 37·50 ± 1·94 min.; *C*, 45·12 ± 2·78 min.; *D*, 30·50 ± 1·09 min. Both the deficient and the operated rats (*A* and *C*) were more resistant than groups *B* and *D*, although, of these, the pair-fed rats *B* were more resistant than the controls fed *ad lib.* (*D*). There was no significant difference in resistance between groups *A* and *C*. Groups *A* and *C* were more variable than group *B*, itself more variable than the controls fed *ad lib.* (*D*).

The effects of pantothenic acid deficiency on oxygen poisoning thus resemble those of adrenalectomy. The problem of the variability of response in these animals remains unsolved. That the diet was effective was shown by the six deaths, by greying of the fur and by the relative failure of the rats to grow; but there was no evidence that time to onset of severe poisoning was related to body-weight. There was no relationship between weight of suprarenal tissue and time to onset of severe poisoning in group *A*, but three of the four most resistant animals had glands which were obviously hæmorrhagic. It is not clear how to determine precisely, in terms of cortical function, the response of individual rats to the pantothenic acid-deficient diet, and thus one source of variability may have been substituted for another. Or it may be that the variability is due to a highly complex relationship between suprarenal cortical function and response to exposure to oxygen under high pressure.

I am indebted to Mr. R. M. Cormack of the Department of Statistics, University of Aberdeen, for help in the design and analysis of the experiments.

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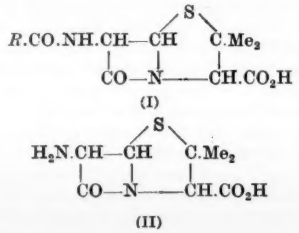
[1] Morgan, A. F., and Simms, H. D., *Science*, **89**, 505 (1939).
[2] Hurley, L. S., and Morgan, A. F., *J. Biol. Chem.*, **195**, 583 (1952).
[3] Bean, J. W., Johnson, P., and Smith, C. W., Abstr. Nineteenth Int. Physiol. Congr., 945 (1953).
[4] Gerschman, R., and Nadig, P. W., *Fed. Proc.*, **12**, 159 (1953).
[5] Taylor, D. W., Abstr. Nineteenth Int. Physiol. Congr., 821 (1953).
[6] Taylor, D. W., *J. Physiol.*, **140**, 23 (1958).
[7] Taylor, D. W., *J. Physiol.*, **140**, 37 (1958).

Synthesis of Penicillin: 6-Aminopenicillanic Acid in Penicillin Fermentations

The work reported here stemmed from the experiments described in an earlier communication[1] on *p*-aminobenzylpenicillin, in which discrepancies were observed between chemical and biological methods of penicillin assay when a precursor was omitted from penicillin fermentations.

The various penicillins (formula I) may all be regarded as acyl derivatives of a common parent amine, 6-amino-penicillanic acid (formula II: for nomenclature see Sheehan *et al.*[2]). We wish to report the isolation of pure 6-amino-penicillanic acid from penicillin fermentations carried out in the absence of added side-chain precursor, the culture used being an isolate from *Penicillium chrysogenum W*.51.20.



(I)

(II)

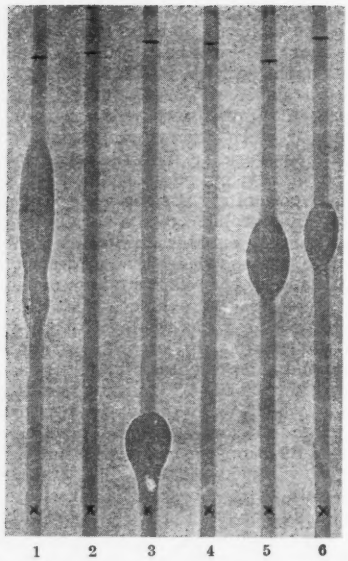


Fig. 1. Chromatograms of fermentation liquors. 1, Filtrate of fermentation carried out in the absence of side-chain precursors; 2, filtrate as (1) after extraction with butyl acetate at *p*H 2·0; 3, as (2) but the chromatogram sprayed with aqueous sodium bicarbonate and an acetone solution of phenylacetyl chloride before developing on the seeded agar plate; 4, solvent-extracted filtrate as (2) treated with penicillinase before chromatography and then sprayed with the solutions of sodium bicarbonate and phenylacetyl chloride as in (3); 5, solvent-extracted filtrate, as (2), treated with sodium bicarbonate and phenylacetyl chloride before chromatography; 6, penicillin *G*. Solvent: butanol/ethanol/water, 40 : 10 : 50, top layer; Whatman No. 1, running time 15 hr.

The presence of (II) was first indicated when such a fermentation liquor, after removal of natural penicillins by solvent extraction at low *p*H, was treated with an excess of phenylacetyl chloride in the presence of a weak base such as sodium bicarbonate. This resulted in the formation of an antibiotic substance which was readily destroyed by penicillinase and which behaved similarly to penicillin *G* on paper chromatograms. Similarly, reaction with phenoxyacetyl chloride resulted in the formation of an antibiotic resembling pencillin *V* in its stability in acid solution as well as its behaviour on paper chromatograms. The reaction with phenylacetyl chloride in the presence of sodium bicarbonate was readily adapted to the detection of (II) on paper chromatograms (Fig. 1) which were sprayed with the appropriate reagents before plating on agar seeded with a sensitive bacterium in the usual way. This conversion of (II) to benzylpenicillin on paper strips also provided a convenient method of assay, being similar to the well-known paper disk method.

Pure crystalline 6-aminopenicillanic acid, details of the isolation of which will be reported at a later date, had m.p. 208–209° C. (decomp.) (found: C, 44·6; H, 5·7; N, 13·1; S, 14·1 per cent; $C_8H_{12}O_3N_2S$ requires C, 44·4; H, 5·6; N, 13·0; S, 14·8 per cent). Phenylacetylation and subsequent biological assay on paper as outlined above gave 2,740 units of benzylpenicillin per mgm. of starting material (theory 2,752 units/mgm.). 6-Aminopenicillanic acid itself possesses definite antibacterial properties, but these are mostly of a much lower order than those of benzylpenicillin, and the spectrum is of a different type. It is destroyed by penicillinase (*Bacillus cereus* broth filtrate) but at a much slower rate than is benzylpenicillin. Like the penicillins it is rapidly decomposed by strong alkali, but as would be expected from its structural inability to undergo rearrangement to a penillic acid, it is relatively stable to acids. The compound is itself a surprisingly strong acid, the isoelectric point being about 4·3.

Chemical evidence supporting the structure (II) has been obtained by treatment of the substance with ethyl chloroformate to give a crude N-carbethoxy derivative (I; R = EtO) which was degraded by the general method of Dutcher *et al.*[3] to N-carbethoxyaminoacetaldehyde 2 : 4-dinitrophenylhydrazone (51 per cent overall yield), bright yellow micro-needles from alcohol, m.p. 174–175° C., not depressed by admixture with a specimen synthesized from aminoacetal (found: C, 42·2; H, 4·2 per cent; $C_{11}H_{13}O_6N_5$ requires C, 42·4; H, 4·2 per cent).

Furthermore, the benzylpenicillin which had been prepared by phenylacetylation of (II) was isolated as the N : N′-dibenzylethylenediamine salt, which after crystallization from acetone had m.p. 114–115° C., not depressed by admixture with an authentic specimen[4] (found: C, 59·4; H, 6·8; N, 9·0; S, 6·5 per cent; calc. for $C_{48}H_{56}O_8N_6S_2.3H_2O$: C, 59·8; H, 6·5; N, 8·7; S, 6·7 per cent). A portion of this same phenylacetylation product was degraded to benzylpenilloaldehyde, which was isolated as the 2 : 4-dinitrophenylhydrazone, m.p. 196° C., not depressed by admixture with an authentic specimen[3].

Various authors have expressed the view that the last stage in penicillin biosynthesis is the introduction of the acyl side-chain[5]. Our isolation of 6-aminopenicillanic acid is consistent with this view, but does not preclude the possibility of it arising during fermentation, either as an alternative metabolite or by enzymatic hydrolysis of a penicillin[6]. The substance is nevertheless a most useful chemical intermediate for the preparation of new penicillins and related compounds which are not easily accessible in other ways. The possible therapeutic usefulness of such derivatives is being investigated in these Laboratories (patent application pending, 1957).

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Nov. 26.

[1] Ballio, A., Chain, E. B., Dentice di Accadia, F., Rolinson, G. N., and Batchelor, F. R., *Nature*, **183**, 180 (1959).

[2] Sheehan, J. C., Henery-Logan, K. R., and Johnson, D. A., *J. Amer. Chem. Soc.*, **75**, 3292 (1953).

[3] "The Chemistry of Penicillin", 481 (Princeton University Press, 1949).

[4] Szabo, J. L., and Bruce, W. F., U.S. Patent 2,627,491; *Chem. Abst.*, **48**, 734 (1954).

[5] Hockenhull, D. J. D., Ramachandran, K., and Walker, T. K., *Arch. Biochem.*, **23**, 160 (1949). Burger, A., "Medicinal Chemistry", 2, 880 (Interscience Pub., 1951). Kato, T., *Kagaku (Science)*, **23**, 217 (1953); *J. Antibiotics* (Japan), **6**, A. 130, 184 (1953). Abraham, E. P., *Giornale di Microbiologica*, **2**, 102 (1956). Arnstein, H. R. V., and Crawhall, J. C., *Biochem. J.*, **67**, 180 (1957).

[6] Sakaguchi, K., and Murao, S., *J. Agric. Chem. Soc. Japan*, **23**, 411 (1950). Murao, S., *Nippon Nogei-kagaku Kaishi*, **29**, 400, 404 (1955).

A Microsomal Malic Dehydrogenase

C. F. Strittmatter and Ball[1] have localized a hæm protein in liver microsomes which they have termed 'cytochrome *m*'. This hæmochromogen was first studied by Keilin and Hartree[2] in liver homogenates and was termed by them cytochrome b_1. Pappenheimer and Williams[3], who studied this pigment in the *Cecropia* larvæ, have designated it 'cytochrome b_5'. P. Strittmatter and Velick[4] have isolated this cytochrome from rabbit liver microsomes and studied its properties. These workers[5] have also prepared a reduced diphosphopyridine nucleotide–microsomal cytochrome reductase from the same cellular material. This reductase is totally inactive with cytochrome *c* but catalyses the transfer of electrons from reduced diphosphopyridine nucleotide to the microsomal cytochrome. The microsomal cytochrome transfers electrons directly to cytochrome *c*. Thus, cytochrome *m* completes a reduced diphosphopyridine nucleotide–cytochrome *c* reductase system which involves an electron transfer from cytochrome to cytochrome.

In spite of the fact that the conventional electron transport system is not complete in the microsomes[6], it was reasoned that since a system exists in liver microsomes for transferring electrons from reduced diphosphopyridine nucleotide to cytochrome *c*, dehydrogenases dependent upon diphosphopyridine nucleotide might also be present in the microsomes. An investigation was therefore undertaken to determine if any such dehydrogenases were present in liver microsomes. The results of this preliminary investigation are reported here.

Assays for D-glucose, L-glutamic, alcohol, and L-malic dehydrogenases were performed on an aqueous homogenate of horse-liver microsomes. The assays were negative for D-glucose, L-glutamic, and alcohol dehydrogenases but positive for L-malic dehydrogenase. Subsequent work was done with microsomes isolated from rat liver. The rat was decapitated, the liver quickly excised, weighed, and then homogenized in cold isotonic sucrose solution. The nuclei were removed in a refrigerated centrifuge at 600*g* for 12 min. The supernatant fluid was centrifuged at 30,000 r.p.m. for 6 min., in a 'Spinco' preparatory ultracentrifuge using a No. 40 head to remove the mitochondria. The microsomes were obtained by spinning the supernatant fluid recovered from the mitochondrial run at 40,000 r.p.m. (110,000*g*) for 35 min. The microsomal pellet was washed several times with distilled water and then homogenized in distilled water.

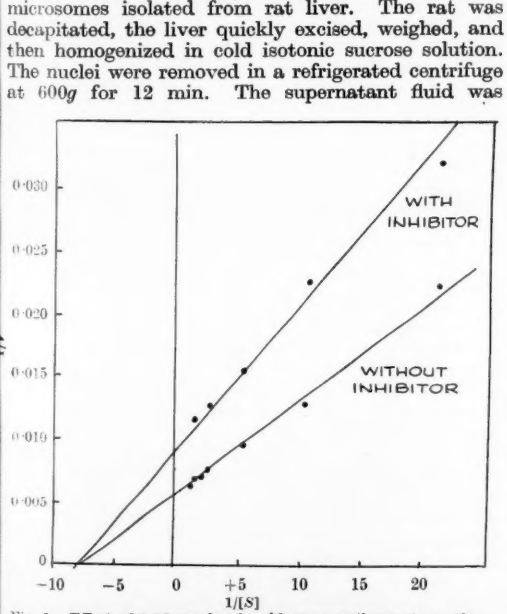

Fig. 1. Effect of 0·15 μmole of *p*-chloromercuribenzoate on the velocity of the microsomal malic dehydrogenase. The ordinate is the reciprocal of the velocity in units (decrease in optical density of 0·01/min.)/mgm. of protein. The abscissa is the reciprocal of the substrate (oxalacetate) concentration in μM

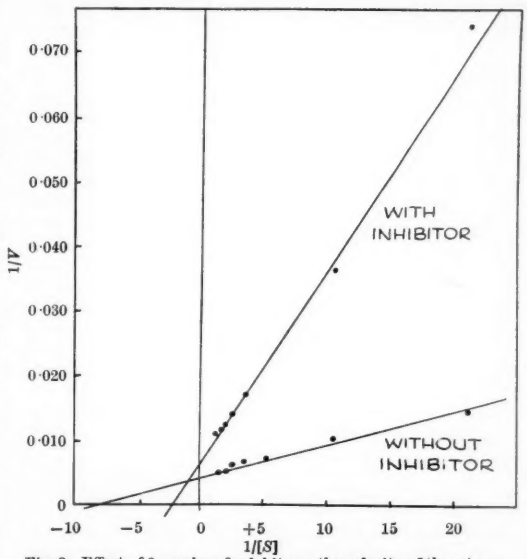

Fig. 2. Effect of 3 μmoles of sulphite on the velocity of the microsomal malic dehydrogenase. The ordinate is the reciprocal of the velocity in units (decrease in optical density of 0·01/min.)/mgm. of protein. The abscissa is the reciprocal of the substrate (oxalacetate) concentration in μM

The microsomes were examined microscopically and were found to be free of mitochondria. Microsomal homogenates made with 2 per cent deoxycholate (*p*H 7·4) and those made with 0·44 *M* sucrose containing 1 μmole of fructose-1,6-diphosphate per ml. were also assayed. Malic dehydrogenase activity was obtained with all microsomal preparations assayed. Malic dehydrogenase was determined by the decrease in optical density at 340 mμ in a Beckman Model *DU* spectrophotometer using Ochoa's method[7]. Each cuvette contained microsomal homogenate, oxalacetate *p*H 7·4, 0·2 *M* phosphate buffer *p*H 7·4, and 0·15 μmole of reduced diphosphopyridine nucleotide in a total volume of 3·0 ml. Four determinations on two different microsomal preparations gave a value of $1{\cdot}4 \times 10^{-7}$ *M* at *p*H 7·4 for the Michaelis constant (*Km*) for oxalacetate. Wolfe and Neilands[8] reported a value of *Km* for L-malate at *p*H 10 of $5{\cdot}5 \times 10^{-5}$ *M*.

The results of a typical experiment for the microsomal malic dehydrogenase in the presence and absence of the –SH group inhibitor, *p*-chloromercuribenzoate, are shown in a Lineweaver–Burk plot[9] in Fig. 1. The characteristics of this plot indicate that *p*-chloromercuribenzoate is a non-competitive inhibitor of oxalacetate for the microsomal malic dehydrogenase. Barron and Singer[10] found that at a concentration of 2×10^{-4} *M* it completely inhibited malic dehydrogenase.

In Fig. 2 a Lineweaver–Burk plot illustrates the effect of sulphite on the velocity of the microsomal malic dehydrogenase. The work of Pfleiderer *et al.*[11] indicates that sulphite is a potent inhibitor of malic

dehydrogenase; a 25 per cent inhibition of this enzyme with 2–10 μgm. of sulphite was reported by these workers. Fig. 2 indicates that sulphite is a competitive inhibitor of oxalacetate for the microsomal malic dehydrogenase. Adenosine triphosphate has been reported by Williams[12] to be a competitive inhibitor of diphosphopyridine nucleotide for malic dehydrogenase; 22 μmole of adenosine triphosphate at an oxalacetate concentration of 0·76 μ*M* caused a 25 per cent inhibition of the microsomal malic dehydrogenase when measured at several concentrations of reduced diphosphopyridine nucleotide. Fumarate at a concentration equal to that of the oxalacetate did not inhibit microsomal malic dehydrogenase[13]. Further investigation of the microsomal malic dehydrogenase and work to determine if other dehydrogenases dependent upon diphosphosphopyridine nucleotide are present in the liver microsomes are now in progress.

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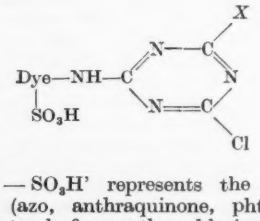
[1] Strittmatter, C. F., and Ball, E. G., *Proc. U.S. Nat. Acad. Sci.*, **38**, 19 (1952).
[2] Keilin, D., and Hartree, E. F., *Proc. Roy. Soc.*, B, **129**, 277 (1940).
[3] Pappenheimer, jun., A. M., and Williams, C. M., *J. Biol. Chem.*, **209**, 915 (1954).
[4] Strittmatter, P., and Velick, S. F., *J. Biol. Chem.*, **221**, 253 (1956)
[5] Strittmatter, P., and Velick, S. F., *J. Biol. Chem.*, **221**, 277 (1956).
[6] Strittmatter, C. F., and Ball, E. G., *J. Cell. Comp. Physiol.*, **43**, 57 (1954).
[7] Ochoa, S., in "Methods in Enzymology", edit. Colowick, S. P., and Kaplan, N. O., **1**, 735 (Acad. Press, Inc., New York, 1955).
[8] Wolfe, R. G., and Neilands, J. B., *J. Biol. Chem.*, **221**, 61 (1956).
[9] Lineweaver, H., and Burk, D., *J. Amer. Chem. Soc.*, **56**, 658 (1934).
[10] Barron, E. S. G., and Singer, T. P., *J. Biol. Chem.*, **157**, 221 (1945).
[11] Pfleiderer, G., Jeckel, D., and Wieland, T., *Biochem. Z.*, **328**, 187 (1956).
[12] Williams, jun., J. N., *J. Biol. Chem.*, **195**, 629 (1952).
[13] Straub, F. B., *Z. physiol. Chem.*, **275**, 63 (1942).

Labelling of Proteins with Cellulose-reactive Dyes

In 1923 azo dyes containing a cyanuric halide grouping were introduced by Ciba[1]. In recent years, the practical application of similar reactive compounds possessing a triazine chloride radical has been extended considerably[2,3]. Dyes of this type have the following type of structure:



where 'Dye — SO_3H' represents the sulphonated chromophor (azo, anthraquinone, phthalocyanine, etc.) and *X* stands for another chlorine atom or for an inactive radical. On the fibre, the halogen atom of the dye molecule reacts with the hydroxyl group of the cellulose molecule forming a covalent bond. Reactive dyes of the above type are marketed by Imperial Chemical Industries, Ltd., and by Ciba.

Dyes bearing the dichloro-triazinyl grouping have been successfully employed by us for labelling antigens such as ovalbumin, serum albumin and gamma-globulin. The dye was coupled to the crystalline protein in 0·85 per cent sodium chloride at *p*H 7·4 for 30–60 min. at 20–22° C. Unfixed dye, resulting from a side-reaction of triazinyl chloride with water, was removed by dialysis at 4° C. against 0·06 *M* phosphate buffered saline *p*H 7·4. The dyes were used for coupling in concentrations of 1–10 per cent of the weight of protein. At the *p*H employed, the dye molecule can be expected to react with free amino-groups of the protein. Binding of dye to protein was not accelerated by using a strongly alkaline *p*H. In the case of serum albumin, the electrophoretic pattern obtained with a protein conjugate containing 5 per cent dye was identical to that of the pure protein. Cross-linking, as estimated by the appearance of turbidity in the conjugate-containing solution, was negligible with dyes possessing one dichloro-triazinyl grouping, but was marked with compounds containing two such radicals. It is probable, therefore, that only one chlorine atom of the dichloro compound is reactive under the conditions employed.

The firm chemical linkage that results between the reactive group of the dye and the protein could be demonstrated by a method described by Vickerstaff[4]. A yellow reactive dye possessing an azo chromophor was coupled to ovalbumin. After reduction with sodium hydrosulphite the bleached product containing free amino-groups from the split azo linkage was diazotized and afterwards coupled with naphthol *AS*. This procedure resulted in the formation of a new dye and in a change of the yellow colour of the protein conjugate to a dark red.

For the tracing of antigens in tissue sections, some of the more highly coloured reactive dyes containing the dichloro-triazine grouping gave good results (Fig. 1). The best results, however, were obtained by using similar reactive compounds possessing a fluorescent chromophor. Fig. 2 shows protein absorption droplets in a proximal convoluted tubule of mouse kidney 18 hr. after intraperitoneal injection of ovalbumin labelled with a fluorescent compound. Preliminary experiments with anti-gamma-globulin have shown that the present method can be used for labelling of antibodies and for the demonstration of antigen–antibody reactions in tissue sections.

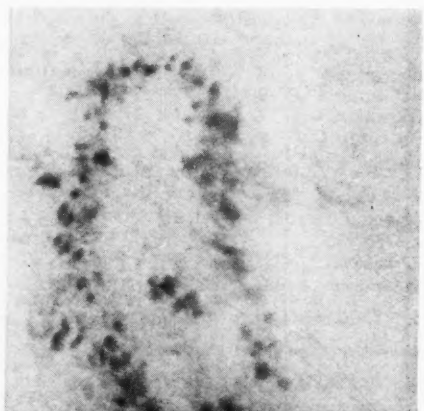


Fig. 1. 8-μ cold microtome section of mouse kidney, 18 hr. after intraperitoneal injection of ovalbumin labelled with a coloured dichloro-triazinyl dye. (× 1,400)

Fig. 2. 8-μ cold microtome section of mouse kidney, 18 hr. after intraperitoneal injection of ovalbumin labelled with a fluorescent dichloro-triazinyl dye. (× 1,100)

The labelling of proteins with reactive dyes is simple and offers considerable advantages over current methods of conjugating proteins through azo[5] and ureido[6] linkages. In a series of preliminary tests with fluorescent or coloured dyes containing other reactive groups (sulphon-β-chloroethylamide, sulphon fluoride, thiocyano, chloroacetylamino, γ-chloro- β-hydroxypropyl) the superiority of the dichloro-triazinyl group appears to be established. These studies are being continued and extended.

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[1] U.K. Patent Specification No. 209723 (1923).
[2] Vickerstaff, T., *Melliand Textilber.*, **39**, 905 (1958).
[3] Schlaeppi, F., *Amer. Dyestuff Reptr.*, **47**, 377 (1958).
[4] Vickerstaff, T., *J. Soc. Dyers and Col.*, **73**, 237 (1957).
[5] Kabat, E. A., and Heidelberger, M., *J. Exp. Med.*, **66**, 229 (1937).
[6] Coons, A. H., Creech, H. J., Jones, R. N., and Berliner, E., *J. Immunol.*, **45**, 159 (1942).

Reversal of Antibiotic Action of Cycloheximide (Actidione) by Bivalent Metal Ions

Cycloheximide, an antibiotic with selective inhibitory effect on many fungi[1,2] but inactive against bacteria, has received increased attention during recent years, but few reports are concerned with its mode of action. Cycloheximide inhibits aerobic utilization of many intermediates of carbohydrate metabolism by *Tetrahymena pyriformis*[3], and it is active against higher plants[4]. Kerridge[5] has observed that fungistatic doses of cycloheximide (0·5–1·0 μgm./ml.) have no marked effect on fermentation and respiration of *Saccharomyces mandshuricus*, but synthesis of protein and deoxyribonucleic acid is completely blocked. On the other hand, Greig *et al.*[6] have recently announced that in the case of *Saccharomyces cerevisiae* the same antibiotic shows an inhibitory effect on fermentation.

This communication presents the results of a study of the inhibitory action of cycloheximide on growth and respiration of a sensitive strain of *Candida krusei* and a resistant strain of *Candida albicans*. Previous authors employed agar plate techniques for measurement of growth; in the present work growth was estimated turbidimetrically. Cultures were incubated for 22 hr. with forced aeration at 28° C. in a liquid medium containing glucose and mineral salts.

The results of experiments on growth show that 0·5 μgm./ml. of cycloheximide has a marked antibiotic effect while 2 μgm./ml. inhibit completely the multiplication of *C. krusei*. The growth of the resistant *C. albicans* was not altered by concentrations of antibiotic up to 100 μgm./ml. The activity of antibiotic remained unchanged when ammonium sulphate in the medium was replaced by other nitrogen sources, such as amino-acids, peptides and protein hydrolysates. Curiously enough, the only exception was peptone which, in a concentration of 1 per cent, almost completely suppressed the inhibitory action of cycloheximide. The degree of inhibition depended on the origin of the peptone employed and was due not to the organic components but to iron. When the heavy metals in peptone were precipitated by hydrogen sulphide the reversal of inhibition did not occur; when ferrous iron alone was added to the mineral medium with inorganic source of nitrogen, the inhibitory effect of cycloheximide was suppressed.

The reversal of inhibitory activity was also demonstrated in manometric experiments with washed suspensions of *C. krusei*. Cycloheximide at a concentration of 0·5 μgm./ml. caused 40 per cent inhibition of the rate of oxidation of glucose by intact cells. In the presence of 2×10^{-4} *M* $FeSO_4.7H_2O$ and 0·5 μgm./ml. of cycloheximide the respiration was even faster than in the control without antibiotic. Manganese or zinc, like iron, antagonized the inhibitory effect of antibiotic; calcium, magnesium or cadmium were less active and copper had no detectable effect. Respiratory activity of washed cells of *C. albicans* was not influenced by cycloheximide.

These observations suggest that cycloheximide forms chelates with bivalent metals and that these complexes are antibiotically inactive. This phenomenon of chelate formation is not unique among antibiotics, and the subject has been well summarized in a review by Weinberg[7]. He, as well as Whiffen[2], did not report any influence of metals in the case of cycloheximide; but Greig *et al.*[6] observed potentiation of the inhibitory effect of this antibiotic on fermentation by *Saccharomyces cerevisiae*. This apparent discrepancy concerning the mode of action of metals on antibiotic potency of cycloheximide seems to be due not only to the use of different organisms but also to different criteria and methods employed.

Details of these experiments will be published elsewhere.

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[1] Walker, A. T., and Smith, F. G., *Proc. Soc. Exp. Biol. Med.*, **81**, 556 (1952).
[2] Whiffen, A. J., *J. Bact.*, **56**, 283 (1948); *Mycologia*, **42**, 253 (1950). Whiffen, A. J., Bohonos, N., and Emerson, R. L., *J. Bact.*, **52**, 610 (1946).
[3] Mefferd, R. B., and Loefer, J. B., *Physiol. Zool.*, **27**, 115 (1954); *Proc. Soc. Protozool.*, **3**, 17 (1952).
[4] Wilson, G. B., *J. Hered.*, **41**, 227 (1950).
[5] Kerridge, D., *J. Gen. Microbiol.*, **16**, 5 (1957).
[6] Greig, M. A., Walk, R. A., and Gibbons, A. J., *J. Bact.*, **75**, 489 (1958).
[7] Weinberg, E. D., *Bact. Rev.*, **21**, 46 (1957).

Determination of Nitrogen in Proteins by means of Indanetrione Hydrate

The determination of nitrogen in organic substances has been performed by either of the well-established methods, namely, one attributed to Dumas or the other first described by Kjeldahl. These methods require approximately 300 μgm. of nitrogen for accurate determination. The method to be described requires much less material, and compares favourably in accuracy with these standard methods. The sample is decomposed by digestion in sulphuric acid, and the ammonia is determined quantitatively by means of indanetrione hydrate.

The sample (for example, 0·05–0·10 ml. serum) is digested in 0·5–1·0 ml. sulphuric acid to which is added 3–5 mgm. of a mixture of copper sulphate (microanalytical reagent), potassium sulphate (microanalytical reagent), mercuric oxide (laboratory grade) and selenium (5 : 15 : 5 : 1 parts by weight respectively). The sample is heated in a standard Kjeldahl flask for 45 min., when it should have cleared. If the acid digest is not clear after 45 min., the flask is cooled, 0·2 ml. of hydrogen peroxide solution (100 vol. B.D.H., microanalytical reagent) is added drop by drop and the contents of the flask are re-heated. The solution becomes clear immediately and the heating is continued for 2 hr.

The digested sample is dissolved in 0·4 *M* sodium citrate buffer solution *p*H 5·0 (25 ml. buffer solution for 0·5 ml. sulphuric acid : 50 ml. buffer solution for 1·0 ml. sulphuric acid). An aliquot, normally 0·5 ml., of this solution, diluted further if necessary with buffer solution to make 2·0 ml., is mixed with 2·0 ml. of a 2 per cent indanetrione hydrate solution. (2·0 gm. indanetrione hydrate : 50 ml. methyl 'Cellosolve' : 25 ml. 4·0 *M* sodium acetate buffer solution *p*H 5·5 (544 gm. sodium acetate trihydrate + 100 ml. glacial acetic acid per litre) : 25 ml. water : 0·08 gm. stannous chloride dihydrate (analytical reagent).) The mixture is heated in a water bath at 100° C. for 30 min., cooled and diluted with 6 ml. of a solution of ethanol/water (1 : 1 by volume).

When determined in a Uvispek spectrophotometer, a solution containing 0·4 μ*M* of ammonia (=5·6 μgm. nitrogen) has an optical density of 0·805 (±0·008) for 1 cm. path-length at a wave-length of 570 mμ. The optical density of the control solution, that is, 1·0 ml. sulphuric acid (microanalytical reagent) diluted in the same manner, varies between 0·045 and 0·060.

Column 1 of Table 1 shows typical analyses of a serum from a normal rhesus monkey performed by the indanetrione hydrate method. Column 2 shows analyses of the same serum by the standard micro-Kjeldahl method.

Table 1

Indanetrione hydrate	Micro-Kjeldahl
11·3 mgm. N per ml.	11·3 mgm. N per ml.
11·3	11·4
11·4	11·3

The method has been used for routine purposes and is found to be more reliable than the standard micro-Kjeldahl method. The aliquot, examined in triplicate if necessary, contains only one-fiftieth or one-hundredth part of the original nitrogen. Work is in progress to apply this method to the quantitative determination of nitrogen in other nitrogenous compounds following their digestion in sulphuric acid.

The indanetrione hydrate may be purified without loss by the method already described[1]. The presence of traces of cations in the digest solution, due to the catalyst, does not affect the colour development (cf. Meyer and Riklis[2]) during the reaction between the ammonia and the indanetrione hydrate. Wherever possible, analytical reagents are used and all solutions are prepared with conductivity water obtained by de-ionizing once-distilled water[3]. In our experience the analytical reagent most likely to produce high values of optical density with the control solution is sodium acetate : but this compound may be easily purified by re-crystallization from ethyl alcohol to yield satisfactory values of optical density with the control solution.

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[1] Jacobs, S., *Analyst*, **81**, 502 (1956).
[2] Meyer, H., and Riklis, E., *Nature*, **172**, 543 (1953).
[3] Jacobs, S., *Chem. and Indust.*, 944 (1955).

Replacement of Thiamine as a Growth Factor for *Mycobacterium butyricum*

Thiamine is recognized as a growth factor for many micro-organisms. Some micro-organisms require the presence of the whole thiamine molecule whereas others are able to synthesize either the pyrimidine or thiazole moieties. In some instances, cells are unable to use either component, but if supplied with the two fragments can combine the two into the complete molecule. Pyrithiamine (1-[(4-amino-2-methyl)-5-pyrimidylmethyl]-2-methyl-3 (α-hydroxyethyl) pyridinium bromide) is a thiamine analogue in which a pyridine ring replaces the thiazole moiety. This analogue has an anti-thiamine effect in some micro-organisms, and in others it can replace thiamine by acting as a source of the pyrimidine ring[1,2].

Thiamine is required for the growth of *Mycobacterium butyricum* in chemically defined media[3]. This requirement has been examined by growing *M. butyricum* (No. 337, National Collection of Type Cultures, Lister Institute, London) on a synthetic medium containing inorganic salts with glycerol as a carbon source and ammonium sulphate as a nitrogen source. To this medium was added thiamine hydrochloride, 4-amino-5-aminomethyl 2-methyl pyrimidine 2 hydrochloride, 5-(2-hydroxyethyl) 4-methyl thiazole, or pyrithiamine. The medium was sterilzed by autoclaving at 15 lb. for 15 min. The flasks (500 ml.) containing 100 ml. of medium were inoculated with a washed suspension of cells (0·4 mgm. dry wt.) and the cultures incubated aerobically at 38° for nine days. Growth was estimated by filtering off the cells, washing well with distilled water and drying at 105° in weighed crucibles.

Only a slight growth was observed in the absence of thiamine or with the thiazole fragment (Table 1). Good growth occurred with thiamine, with the pyrimidine moiety, with the pyrimidine plus thiazole moieties, or with pyrithiamine. Since the pyrimidine fragment seems to be essential for growth, it was considered possible that pyrithiamine was exerting its effect due to hydrolysis on autoclaving. This was tested by adding to the growth medium pyrithiamine sterilized by autoclaving or by filtering through a glass filter (porosity 5), or by adding directly from its bottle to the sterile medium. No difference was noted in the growth response to autoclaved, filtered or unsterilized pyrithiamine.

These results demonstrate the inability of *M. butyricum* to synthesize the pyrimidine moiety of thiamine at a sufficient rate to promote normal

Table 1. THE REPLACEMENT OF THIAMINE AS A GROWTH FACTOR FOR *Mycobacterium butyricum*

Addition to medium	Concentration of addition (μgm./100 ml.)	Bacterial growth (mgm. dry weight)
No addition	—	20
Thiamine	200	114
Thiamine	1,000	119
Pyrimidine fragment	100	101
Pyrimidine fragment	500	106
Thiazole fragment	100	20
Thiazole fragment	500	24
Pyrimidine plus thiazole fragments	100	102
	500	110
Pyrithiamine	200	117
Pyrithiamine	1,000	122

growth. Presumably the bacteria can split pyrithiamine and utilize the pyrimidine portion. Martin[4] has reported similar findings with *Nocardia corallina*, an organism related to the *Mycobacteria*, and Lutz[5,6] has shown that the thiamine requirement of *M. phlei* and *M. paratuberculosis* could be replaced by the pyrimidine moiety for the former and by the pyrimidine moiety or pyrithiamine for the latter organism.

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[1] Knight, B. C. J. G., "Vitamins and Hormones", **3**, 129 (1945).
[2] Woolley, D. W., and White, A. G. C., *J. Exp. Med.*, **78**, 489 (1943).
[3] Hunter, G. J. E., *J. Bact.*, **66**, 676 (1953).
[4] Martin, J. K., Ph.D. thesis, Univ. of New Zealand (1956).
[5] Lutz, A., *Bull. Soc. Chim. Biol.* (Paris), **30**, 330 (1948).
[6] Lutz, A., *C.R. Acad. Sci. Paris*, **226**, 281 (1948).

Aminopeptidase Activity in Cancer Cells

THE enzyme, aminopeptidase, was included in an investigation on histochemically demonstrable enzyme activities in human pathological lesions. This enzyme was demonstrated by Burstone's method[1] except that cryostat sections were used which were fixed for 5 min. in acetone.

Some observations on aminopeptidase activity in tumours have appeared[2,3]. The authors of these publications mention the high aminopeptidase activity in the stroma around invading tumour cells; but they saw only little activity in the tumour cells.

At present, we have investigated the aminopeptidase activity in about sixty human neoplasms, surgically removed. We can confirm the observations on aminopeptidase activity in some parts of the stroma around the tumour cells. This was especially the case in epidermoid carcinoma, for example, of the lung (eight cases). However, the most striking observation we made was the very high aminopeptidase activity in the tumour cells in each of four cases of gastric carcinoma and in two cases of carcinoma of the bile ducts. After a very short incubation (5 min.) of the acetone-fixed sections in the substrate, activity was demonstrated by the brilliant red coloration developed.

The gastric carcinomas were of different types. The first case was an anaplastic carcinoma of the stomach with metastases in the regional lymph nodes. In the sinus of these lymph nodes many tumour cells of the signet cell type could be seen. In the anaplastic cells of the primary tumour as well as in the signet cells of the lymph nodes a high aminopeptidase activity was observed (Fig. 1).

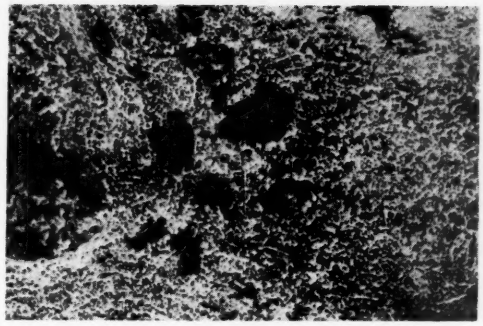

Fig. 1. Groups of signet cells in a lymph node with a high aminopeptidase activity

In the second operation specimen a well-differentiated adenocarcinoma infiltrated the muscle layers of the stomach wall. These tumour cells all showed high aminopeptidase activity in their luminal borders (Fig. 2).

In the third case of a poorly differentiated adenocarcinoma, we observed a high aminopeptidase activity throughout the protoplasm of many tumour cells.

The fourth gastric carcinoma was obtained from an autopsy. In the stomach an ulcerating carcinoma was found, about 2 cm. in diameter. In the lymph nodes the tumour cells showed high enzyme activity.

In some cases of atrophic gastritis combined with a peptic ulcer the epithelial cells show no aminopeptidase activity except for some islands of positive cells of the surface epithelium and in the crypts. These islands are more numerous in the prepyloric region, while in the duodenum and small intestine all epithelial cells show a high aminopeptidase activity along their luminal border.

In a peptic ulcer, aminopeptidase activity was only seen in the granulation tissue of the bottom.

In a normal human stomach no enzyme activity was found in the epithelial cells. In normal lymph nodes and in lymph nodes with proliferation of the reticulum cells only some scattered reticulum cells with aminopeptidase activity were seen. This activity is not as high as in the cells of the gastric cancer; moreover, no groups of positive cells were seen in these lymph nodes.

Both carcinomas of the bile duct were of the anaplastic type. Most of the tumour cells stood out clearly by their high enzyme activity. In the

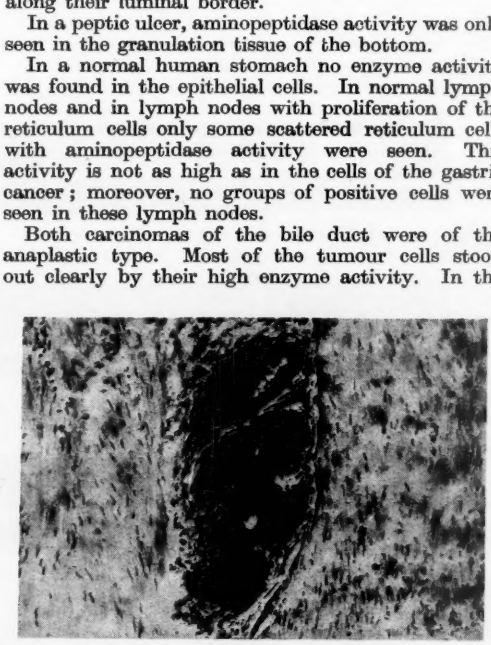

Fig. 2. Aminopeptidase activity in luminal border of tumour cells of an adenocarcinoma

normal epithelium of the human gall bladder and bile ducts there is high aminopeptidase activity in the luminal borders of the cells. Hitherto none of the other tumours has shown aminopeptidase activity.

On the basis of these observations we think that it is worth while to apply this histochemical method for aminopeptidase activity in fresh surgical specimens: (1) in lymph node biopsies with metastatic tumour cells, to investigate the possibility of gastric or bile duct origin; (2) during operations for gastric and bile duct carcinoma, to detect tumour cells in regional lymph nodes and surgical margins.

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[1] Burstone, M. S., and Folk, J. E., *J. Histochem. and Cytochem.*, **4**, 217 (1956).
[2] Burstone, M. S., *J. Nat. Cancer Inst.*, **16**, 1149 (1956).
[3] Braun-Falco, O., *Klin. Wochensch.*, **35**, 50 (1957).

Recording Inhibition and Excitation in the Cat's Retinal Ganglion Cells with Intracellular Electrodes

In the light-adapted state, the receptive fields of retinal ganglion cells in the cat consist of excitatory and inhibitory areas. Thus predominantly excitatory and inhibitory pathways converging on a ganglion cell can be stimulated selectively[1] and thereby the mechanism of excitation and inhibition can be studied. It has recently become possible to record from retinal ganglion cells with intracellular leads for short periods[2]. In the present study, penetrations into cells were fairly frequent; but most cells gave injury discharges and their membrane potentials declined within several minutes. However, intracellular records from some ganglion cells were recorded with stable membrane potentials of 50–70 mV. for as long as 20 min. Discharge patterns were similar to those obtained during extracellular recordings.

The following typical changes were seen in the membrane potential and in the discharge patterns of ganglion cells in the light-adapted state. If in an 'on'-centre receptive field a light spot was shone in the centre of the field, a maintained graded depolarization was set up, accompanied by an increase in frequency of impulses (Fig. 1*A*). The magnitude of the maintained depolarization as well as the discharge-rate were graded according to the strength of illumination. When the light was turned off the membrane potential and discharge frequency gradually returned to original levels. If an annular-type stimulus was used, throwing light only on the outer portion of the same receptive field, the maintained background activity was suppressed. At the same time the membrane potential of the cell was increased (Fig. 1*B*). As the light was turned off, there was a further increase of the membrane potential, followed by depolarization and an off discharge. In Fig. 1*C* the entire receptive field was illuminated, resulting in an interaction between the excitatory and inhibitory portions. The excitatory component predominated, but was much less effective than if the centre alone (as in Fig. 1*A*) was illuminated. Thus stimulation of the entire receptive field caused less impulse activity and less membrane depolarization than illumination of the central portion alone. A marked increase in membrane potential and inhibition of impulse activity occurred as the light stimulus was turned off.

Quite frequently an impaled ganglion cell stopped firing impulses a few minutes after penetration, presumably due to injury by the electrode. But the maintained decrease or increase in the membrane potential could still be observed with appropriate illumination, indicating that these slow potential changes were not dependent on the propagated impulse mechanism.

A few intracellular recordings were obtained from the retinal, presumably unmyelinated, portion of axons of ganglion cells. Membrane potentials were near 50 mV., and the axons were identified by the following criteria. The centre of the receptive field

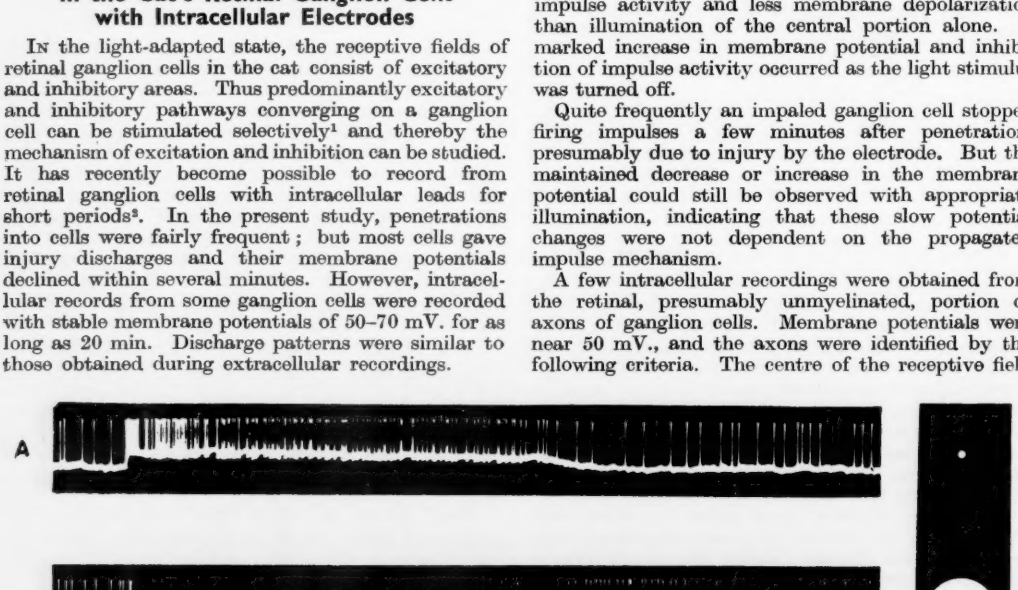

Fig. 1. Intracellular recording from retinal ganglion cell. Membrane potential about 65 mV. Period of illumination marked by arrows. Right, illuminated area marked white. *A*, small light spot of 1° (0·25 mm.) diameter; *B*, annular stimulus, outer diameter 12° (3 mm.) (central area of 1° is not illuminated); *C*, entire receptive field illuminated. Background illumination 0·34 log m.c. Stimulus intensity about 1·85 log m.c.

of such a fibre was some distance from the electrode tip toward the periphery of the retina. The typical slow changes of ganglion cells were absent, the potentials rose sharply and were all or none. Further, there was no sign of synaptic noise which was always present in ganglion cells.

The present observations may be compared with those in a variety of nerve cells. Thus, Eyzaguirre and Kuffler[3], recording from the cell body of the stretch receptor of crayfish, showed corresponding excitatory and inhibitory changes which determined the discharge frequency. Further, Hartline, MacNichol and Wagner[4] and Fuortes[5], leading from the eccentric cell in the *Limulus* eye, described a similar graded depolarization during illumination which was directly related to the discharge frequency. Corresponding slow potentials, both with excitation and inhibition, have been reported by Kolmodin and Skoglund[6] in the motoneurons and interneurons of the cat's spinal cord. The cortical cells studied by Phillips[7] also had similar slow potentials.

The retinal ganglion cells are the final points of convergence from the neuronal network of the receptive fields, which can extend over an area up to several mm. in diameter. The cells can integrate the excitatory and inhibitory synaptic influences in terms of slow changes in their membrane potential. Presumably, these in turn control the discharge frequencies of the optic nerve fibres.

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[1] Kuffler, S. W., *J. Neurophysiol.*, **16**, 37 (1953).
[2] Brown, K. T., and Wiesel, T., *Fed. Proc.*, **17**, No. 1 (March 1958).
[3] Eyzaguirre, C., and Kuffler, S. W., *J. Gen. Physiol.*, **39**, 87 (1955).
[4] Hartline, H. K., Wagner, H. G., and MacNichol, jun., E. F., *Cold Spring Harbor Symp. Quant. Biol.*, **17**, 125 (1932).
[5] Fuortes, M. G. F., *E.E.G. Clin. Neurophysiol.*, Supp. 10, 71 (1958).
[6] Kolmodin, G. M., and Skoglund, C. R., *Acta Phys. Scand.*, **44**, 11 (1958).
[7] Phillips, C. G., *Quart. J. Exp. Physiol.*, **41**, 58 (1956).

Bacterial and Testicular Hyaluronidase

IN papers from this laboratory, the actions on dermal connective tissue[1,2] and on ocular structures[3,4] of different kinds of hyaluronidase have been studied. In these experiments, 'Hyason', manufactured by Organon, Oss, Holland, was used as a source of staphylococcal hyaluronidase. This is also preparation *D* of Chauncey *et al.*[5].

We have recently been informed that batches of 'Hyason' released after January 29, 1958, contain testicular instead of bacterial hyaluronidase and we write this communication in order to prevent confusion arising from the change in composition. The manufacturer keeps a stock of the old preparation, and samples are available for research purposes.

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[1] Juhlin, L., *Acta Pharmacol. et Toxicol.*, **12**, 321 (1956).
[2] Juhlin, L., *Acta Pharmacol. et Toxicol.*, **14**, 1 (1957).
[3] Bárány, E. H., *Acta Ophthalm.*, **34**, 397 (1956).
[4] Berggren, L., and Vrabec, F., *Amer. J. Ophthalm.*, **44**, 200 (1957).
[5] Chauncey, H., Lionetti, F., and Lisanti, V., *Science*, **118**, 219 (1953).

Excitation of the Squid Axon Membrane in Isosmotic Potassium Chloride

THE interesting recent findings in the frog node of Ranvier of an 'action potential' in isosmotic potassium chloride by Müeller[1], and of two stable states in 20–40 m*M* potassium chloride by Stämpfli[2], raise the question as to whether or not similar phenomena are to be found in the squid axon membrane.

I have made a preliminary study of the approximate steady-stage voltage-current relationship for the squid (*Loligo pealii*) giant axon membrane in 0·5 *M* potassium chloride. When the potential was controlled ('*E*-LOC') and varied, a continuous variation of the current is found, including a negative resistance region. The characteristic shape seen in Fig. 1 is typical, although there are some minor variations in the *E–I* curves depending upon the previous potential history and the rate and direction of sweeping. When the current was controlled ('*I*-LOC') and varied the voltage showed the hysteresis loop to be expected about the unstable negative resistance region. This is in complete agreement with Segal's[3] recent finding of two stable potentials for the squid axon membrane in high potassium under current control.

Franck[4] has compiled examples of dynode type characteristics with a negative resistance region which give excitation phenomena. The squid axon membrane in sea water with normal sodium concentration exhibits such a characteristic[5] and gives a normal action potential. Thus, it would also be expected that the squid axon in 0·5 *M* potassium chloride with a similar but displaced characteristic should exhibit excitation under the proper conditions. If the membrane is subjected to a constant hyperpolarizing current, an 'excitation' threshold for superimposed depolarizing current pulses should be found when the net current is less than about 0·15 m.amp./cm.^{2}. Fig. 2 demonstrates the threshold and also shows a recovery so that the process may well be called an 'action potential'.

At present, the description of the processes involved in the 'action potential' in 0·5 *M* potassium chloride seems to be as follows: If the squid axon

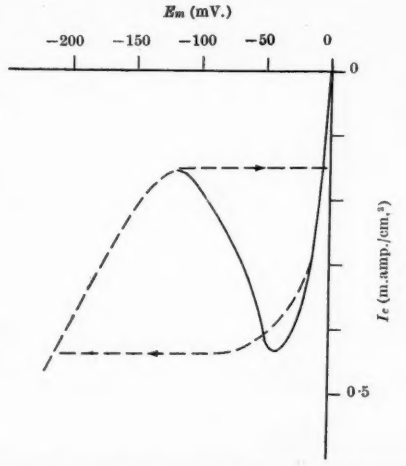

Fig. 1. Voltage-current characteristics of the squid axon membrane in 0·5 *M* potassium chloride. The continuous line was obtained with potential control; the dashed sections with current control. Arrow heads indicate abrupt changes

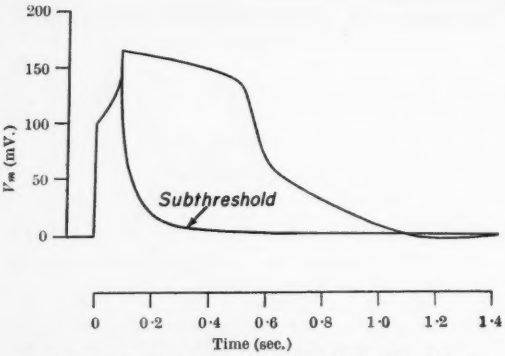

Fig. 2. Time course of an 'action potential' in 0·5 *M* potassium chloride. The membrane was subjected to a constant hyperpolarizing current: additive depolarizing current pulses of about 0·1 sec. of slightly different magnitudes show a threshold

membrane is held near point *A* (in Fig. 3) with a hyperpolarizing current, a pulse of depolarizing current takes the potential up and then along the dashed path at low current; when the pulse is turned off, the membrane potential moves down the right-hand branch of the curve to point *B*. The potential remains in this vicinity until the peak *C* is reduced below the value of the steady current. The potential will then drop back rapidly to point *A*. A possible reason for the shift in the characteristic *E–I* curve and decrease in the peak at *C* is the decrease in potassium concentration in the 'Frankenhaeuser–Hodgkin[6] space' just outside the active membrane. The right-hand branch of the curve through the origin is the characteristic to be expected from 0·5 *M* potassium ion on the Hodgkin–Huxley formulation[7]. The left branch through *A* is probably dominated by the chloride ion conductivity.

The similarities of the frog node[1,8] and squid axon in both normal physiological solutions and isosmotic potassium chloride is highly suggestive of the possibility that similar characteristics are to be found for other excitable membranes with either these or other ions. Outstanding possibilities are chloride ions for *Chara*[9] and barium and strontium ions for crustacean muscle[10].

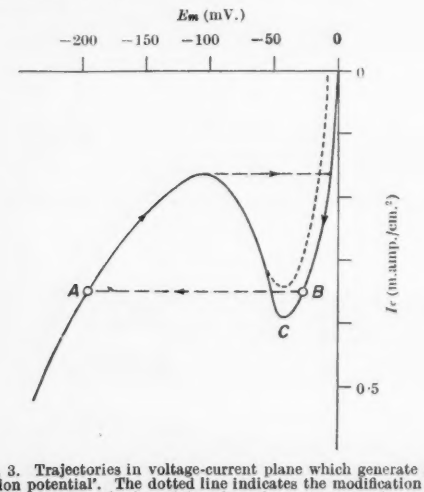

Fig. 3. Trajectories in voltage-current plane which generate an 'action potential'. The dotted line indicates the modification of the branch through the origin when the system remains near the state *B* for about 0·5 sec.

I should like to express appreciation for the co-operation of Drs. K. S. Cole, J. del Castillo and R. E. Taylor in this work, and to the Marine Biological Laboratory, Woods Hole, Massachusetts, for the facilities which made this work possible.

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[1] Müeller, P., *J. Gen. Physiol.*, **42**, 137 (1958).
[2] Stämpfli, R., *Helv. Physiol. Acta*, **16**, 127 (1958).
[3] Segal, J. R., *Nature*, **182**, 1370 (1958).
[4] Franck, U., "Prog. in Biophys.", **6**, 172 (Academic Press, Inc., 1955).
[5] Hodgkin, A. L., Huxley, A. F., and Katz, B., *J. Physiol.*, **116**, 424, Fig. 10 (1952).
[6] Frankenhaeuser, B., and Hodgkin, A. L., *J. Physiol.*, **131**, 341 (1956).
[7] Hodgkin, A. L., and Huxley, A. F., *J. Physiol.*, **117**, 500 (1952).
[8] Dodge, F. A., and Frankenhaeuser, B., *J. Physiol.*, **143**, 76, Fig. 5 (1958).
[9] Gaffey, C. T., and Mullins, L. J., *Fed. Proc.*, **17**, 50 (1958).
[10] Fatt, P., and Ginsborg, B. L., *J. Physiol.*, **142**, 516 (1958).

Influence of Temperature and Light on Reproduction in Male Rats

LIGHT has been considered a gonad-stimulating factor[1], which most probably induces its effect via the pituitary in some animals[2]. It has been reported, though, that some animals respond to light only at a certain season of the year and are refractory to it at other seasons[3]. Autumn breeders, on the other hand, as the goat and sheep, breed at the time of diminishing light[4]. This difference could probably be due to variations in environmental temperature. Another point is that light experiments have usually been done with female animals and with birds. The present investigation was planned to study the effects of temperature and light on reproductive performance in male rats.

Forty-eight mature male rats weighing 180–200 gm. were used. They were divided into six groups of eight animals each. Three groups were kept at the temperature of 18 ± 1° C. and the other three groups were kept at 35 ± 1° C.. Of the groups of animals at each of the two experimental temperatures one was exposed continuously to light of a strength of 30 ft.-candles, another group confined to darkness and the third exposed to 12 hr. of light alternating with 12 hr. of darkness. After 12 days the animals were killed by decapitation under light ether anæsthesia. Their blood was collected, allowed to clot and the serum was obtained by centrifugation at 3,000 r.p.m. for 15 min. The serum was kept in the deep freeze until use. The testes and seminal vesicles were weighed with a torsion balance. The testes were fixed with Susa or Zenker's fluid, stained with hæmatoxylin and eosin or Heidenhain's iron hæmatoxylin, then examined histologically. The content of gonadotrophic hormone of the serum obtained from the different groups of rats was determined by the mouse uterus method[5]. Groups of five immature female mice were injected subcutaneously with 0·5 ml. serum every 12 hr., then killed on the fourth day. The weights of mouse uterus were used as a criterion of gonadotrophic hormone-level in the blood of rats.

The groups of rats kept at the lower temperature of 18° C. had heavier testes and presented a normal picture of spermatogenesis, while the rats kept at the temperature of 35° C. showed partial atrophy of the seminiferous tubules and impaired spermatogenesis. Sertoli cells predominated in the picture and there

Table 1. Influence of Temperature and Light on Testes and Seminal Vesicle Weights of Rats

Treatment	Body-weight	Testes-weight (mgm./100 gm. body-weight)	Seminal vesicle-weight (mgm./100 gm. body-weight)
Cold—light	219	1,001 ± 16·5	244 ± 35·70
Cold—dark	195	932 ± 62·00	112 ± 25·40
Cold—12 hr. light, 12 hr. dark	185	823 ± 66·10	127 ± 33·40
Temperature—light	194	785 ± 50·7	245 ± 44·2
Temperature—dark	227	841 ± 28·3	180 ± 20·2
Temperature—12 hr. light, 12 hr. dark	233	708 ± 70·0	258 ± 40·90

± Standard error

Table 2. Influence of Temperature and Light on Serum Gonadotrophin of Male Rats

Treatment	Mouse uterus-weight (mgm./100 gm. body-weight)
Cold—light	165·57 ± 10·11
Cold—dark	154·56 ± 17·10
Cold—12 hr. light, 12 hr. dark	163·14 ± 20·00
Temperature—light	291·53 ± 24·40
Temperature—dark	200·39 ± 8·66
Temperature—12 hr. light, 12 hr. dark	236·94 ± 17·10
Control mice	110·00 ± 9·16

± Standard error.

were a few spermatogonia cells. The gonadotrophic hormone contents of all rats kept at the high temperature were significantly greater than those of their respective groups kept at the lower temperature. This is in agreement with the results obtained in dogs[6]. Such a rise in the level of gonadotrophic hormone is probably due to decreased utilization of the hormone by the refractory testes.

As appears from the accompanying Tables 1 and 2, the rats exposed to light had significantly heavier seminal vesicles than those of the rats confined to darkness. Exposure to light was also accompanied with an increase in the level of gonadotrophic hormone in the blood and increased amount of interstitial tissue in the testes. This gives evidence of increased production and utilization of luteinizing hormone by exposure to light.

The rats exposed to 12 hr. light and 12 hr. dark had heavier seminal vesicles when kept at 35° C. than those of rats kept at 18° C.

It is thus concluded that exposure to light is accompanied by increased production of gonadotrophic hormone with predominance of luteinizing hormone, whereas exposure to cold is accompanied by increased size of the testes and improved spermatogenesis which is apparently due to a rise in level of follicle-stimulating hormone.

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[1] Amoroso, E. C., and Matthews, L. H., *Brit. Med. Bull.*, **11**, 87 (1955). Rowan, W., *Biol. Rev.*, **13**, 374 (1938).
[2] Hill, M., and Parkes, A. S., *Proc. Roy. Soc.*, B, **113**, 537 (1933).
[3] Bissonnette, T. H., *Physiol. Zool.*, **14**, 379 (1941).
[4] Asdell, S. A., "Patterns of Mammalian Reproduction", 14 (Comstock Publishing Co., Inc., 1946). Hafez, E. S. E., *Nature*, **166**, 822 (1950).
[5] Klinefelter, jun., H. F., Albright, F., and Griswold, C. C., *J. Clin. Endocrinol.*, **3**, 529 (1943).
[6] Soliman, F. A., and Ghanem, Y. S., *Nature*, **179**, 102 (1957).

HISTOLOGY

A New Type of Chromaffin Cells, probably storing Dopamine

von Euler and Lishajko[1,2] have shown that dopamine occurs in the bovine lung in amounts up to 100 times higher than those of noradrenaline. They also demonstrated that the distribution of dopamine —in contrast to that of noradrenaline—was not related to the adrenergic nerves. On the basis of these findings, they concluded that dopamine in the lung cannot merely be an intermediate metabolite in the synthesis of noradrenaline in the adrenergic axons.

Using a new method for determination of catechol amines, Carlsson and co-workers[3,4] systematically charted the occurrence of these amines in various animals. They found large amounts of dopamine in several tissues in ruminants (cow, sheep, goat) but not in any other animals hitherto studied. In view of the relatively large amounts found, Dr. Carlsson asked us to try to demonstrate the cellular localization of this amine by means of histochemical methods. Since dopamine—like adrenaline and noradrenaline—is easily transformed into insoluble dark pigments by oxidation with potassium bichromate[5], an attempt was made to locate this amine by means of the chromaffin reaction.

The tissues were treated with a potassium bichromate–chromate solution (as described previously[6]) with or without formalin. Adjacent pieces of the tissues were fixed in formalin. The pieces were embedded in 'Carbowax' and sections were mounted unstained or after staining with nuclear fast red (Gurr; 0·03 per cent aqueous solution containing 1·7 per cent aluminium sulphate).

Chromaffin cells differing from the classical chromaffin cells of the sympathetic nervous system (presumably storing adrenaline or noradrenaline; cf. von Euler[7]) were observed in several tissues. They were fairly small (6–10μ), round or somewhat elongated and contained fairly large granules (Fig. 1). Though distinct, the chromaffin reaction was rather weak (yellow to yellow-brown). In contrast to all other chromaffin cells examined (adrenal medulla, chromaffin cells in sympathetic ganglia and carotid

Fig. 1. Chromaffin cells in the visceral pleura from the cow. Fixation in bichromate–chromate–formalin. Staining with nuclear fast red. (× 1,200)

body, enterochromaffin cells, the cells of Adams-Ray and Nordenstam[8]), the cells observed had granules, which after treatment with bichromate–chromate–formalin, stained red within a minute with the nuclear fast red solution used and thus showed up well in the tissues.

That the cells are quite different from the enterochromaffin cells, now generally believed to contain 5-hydroxytryptamine, is evident from the following observations. They show the chromaffin reaction after treatment with bichromate without formalin, but the reaction is negative after fixation in formalin. Furthermore, the formalin-fixed cells do not give any diazo reaction (diazotized safranin[9]).

The cells have so far been observed in tissues from cow, sheep and goat; but not from pig, cat, rabbit, guinea pig or rat. Their distribution does not bear any relation to that of the autonomic nerves. In both these respects they are clearly different from the 'common' chromaffin cells of the sympathetic system and the recently discovered cells of Adams-Ray and Nordenstam.

The distribution of the cells follows closely the content of dopamine in the various tissues. Since this will be described in detail elsewhere, only two illustrative examples are mentioned. In the bovine lung the chromaffin cells are abundant in the connective tissue of the visceral pleura but rather scarce in the intrapulmonary tissue. Such cells are likewise relatively abundant in the cow liver capsule but practically absent in the parenchyma. Dopamine determinations (Carlsson and co-workers) showed that the amine content is substantially higher in the pleura than in the intrapulmonary tissue and that it is high in the liver capsule but very low in the parenchyma.

The presence of a new type of chromaffin cells showing a distribution in close accordance with that of dopamine suggests that the cells are storage structures for this amine.

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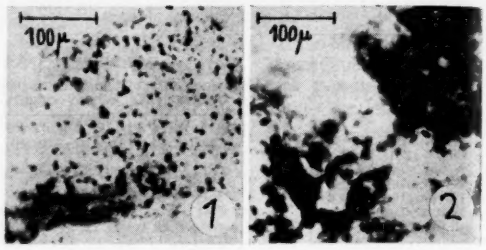
[1] von Euler, U. S., and Lishajko, F., *Acta Physiol. Pharmacol. Neerlandica*, **6**, 295 (1957).
[2] von Euler, U. S., and Lishajko, F., *Acta physiol. Scand.*, **42**, 333 (1958).
[3] Carlsson, A., and Waldeck, B., *Acta physiol. Scand.* (in the press).
[4] Bertler, Å., and Rosengren, E., *Experientia* (in the press).
[5] Hillarp, N.-Å., and Hökfelt, B., *Acta physiol. Scand.* **30**, 55 (1953).
[6] Hillarp, N.-Å., and Hökfelt, B., *J. Histochem. and Cytochem.*, **3**, 1 (1955).
[7] von Euler, U. S., "Noradrenaline" (Springfield, Ill., 1956).
[8] Adams-Ray, J., and Nordenstam, H., *Lyon Chirurgical*, **52**, 125 (1956).
[9] Lillie, R. D., Burtner, H. J., and Greco Henson, J. P., *J. Histochem. and Cytochem.*, **2**, 50 (1954).

Histochemical Demonstration of Lipase and Alkaline Phosphatase Activity in the Fat Body of the Desert Locust

In recent years several workers have studied by histochemical as well as quantitative methods the various metabolites and enzymes of the fat body of the locust. However, no information is available on lipase and alkaline phosphatase activity in this tissue. Here we report the results of a histochemical study undertaken to demonstrate lipase and alkaline phosphatase activity in the fat body of the desert locust (*Schistocerca gregaria*).



Fat body was removed from the abdominal region, after decapitation. The more readily dissected fat bodies thus taken consist mainly, if not solely, of true fat cells, the oenocytes being abundant towards the periphery, adjacent to the body wall[1]. Fresh frozen sections of this tissue was used throughout. For the demonstration of lipase, Gomori's 'Tween' method using 'Tween 80' as substrate was employed. 'Tween 80' is specifically acted upon by 'true lipase'[2]. Alkaline phosphatase was demonstrated employing the revised method of Gomori using sodium glycerophosphate as substrate. The procedures were the same as employed by us in our earlier work[3].

Figs. 1 and 2 present the photomicrographs of sections of the fat body of the locust treated respectively for lipase and alkaline phosphatase activity. Both the enzymes appear to be present in appreciable concentrations. In the case of the sections treated for alkaline phosphatase, there were present numerous round or ovoid bodies which stained intensely for the enzyme. These appeared to be the nuclei. The activity of these enzymes in the fat body is of special interest because this animal is known to utilize chiefly fat for muscular energy[4]. A high lipase activity in its flight muscles has also been recently demonstrated[5]. Similarly, high concentrations of lipase[6] and alkaline phosphatase[7] have been shown to be present in the fat-loaded fibres unlike the glycogen-loaded ones in the pigeon breast muscle, which is also known to utilize mainly fat for energy during sustained muscular activity[8]. Fat bodies of insects are often compared with mammalian liver since a number of metabolic reactions are known to be occurring in them. But more information is essential in order fully to justify such a comparison and the present study is an attempt in that direction.

Grateful thanks are due to Dr. K. B. Lal, plant protection advisor to the Government of India, for arranging the supply of the locusts used in this study.

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[1] Coupland, R. E., *J. Exp. Biol.*, **34**, 290 (1957).
[2] Gomori, G., "Microscopic Histochemistry, Principles and Practice" (Univ. Chicago Press, Chicago, 1953).
[3] George, J. C., and Eapen, J., *J. Anim. Morph. Physiol.*, **5**, 49 (1958).
[4] Weis-Fogh, T., *Phil. Trans. Roy. Soc.*, B., **237**, 640 (1952).
[5] George, J. C., Vallyathan, N. V., and Scaria, K. S., *Experientia*, **14**, 250 (1958).
[6] George, J. C., and Scaria, K. S., *Nature*, **181**, 783 (1958).
[7] George, J. C., Madhavan Nair, S., and Scaria, K. S., *Curr. Sci.*, **27**, 172 (1958).
[8] George, J. C., and Jyoti, D., *J. Anim. Morph. Physiol.*, **4**, 119 (1957).

BIOLOGY

A Rapid Method for examining Diapause Embryos of *Acheta commodus* W.

In the course of current work on the diapause of eggs of the common field cricket *A. commodus* it became necessary to determine the exact stage of embryonic development at which the arrest of development occurs.

Brookes[1] has described a method by which she traced the morphological development of non-diapause embryos of *Acheta*. The method involves fixing, staining and sometimes sectioning the eggs, and may take several weeks to complete.

In the present diapause studies, numerous observations are necessary to determine the onset and duration of diapause at different temperatures, so the long delay in the method used by Brookes would severely limit the scope of the work.

The desirability of using whole eggs rather than sections is evident. Slifer[2] found that by simply immersing eggs of *Melanoplus differentialis* in water the stages during katatrepsis can be observed under a dissecting microscope. However, diapause in *A. commodus* occurs during anatrepsis, the embryo is small and immersed in the yolk, and is not visible by this method.

The following treatment enables large numbers of eggs to be rapidly fixed and cleared in such a way that good optical differentiation of the embryo is provided without the use of stains (Fig. 1).

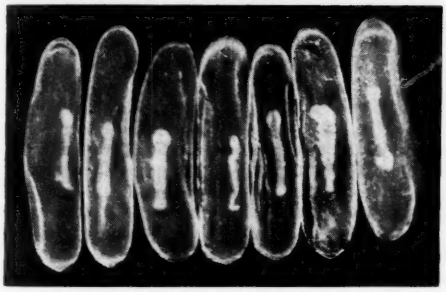

Fig. 1. Embryos of *A. commodus*, showing both diapause and early post-diapause stages of development. (× *c.* 12)

The eggs are placed in a watch box and soaked in water for about ½ hr. The water is then drained off and replaced with the following mixture for 20–30 *min.* at 34° C.: *glacial* acetic, 2 parts; chloroform, 2 parts; absolute alcohol, 1 part. They are then transferred to a mixture of glycerol, 1 part, and alcohol (70 per cent), 1 part.

The first mixture will be recognized as having the same ingredients, in different proportions, as Carnoy's fixative. However, the fixative mixture is not effective. The time necessary in this solution varies with different batches of eggs according to their history, particularly the temperature at which they entered diapause. A preliminary trial for the timing is therefore desirable.

The time in the second solution is not critical. Clarity will be improved by standing at room temperature overnight and the improvement will continue for several days, but the stage of development can be identified within the first hour.

After the treatment the embryos are visible to the naked eye, but, for details of their morphology, the examination is made under a dissecting microscope. A black background and incident light are essential. Careful attention should be paid to the angle of incidence of the light.

I am indebted to Miss J. E. Kenyon for help in developing the method.

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[1] Brookes, H. M., *Trans. Roy. Soc. South Aust.*, **75**, 150 (1952).
[2] Slifer, E. H., *Science*, **107**, 152 (1948).

Influence of Larval Population Density on Fluctuation in Mosquito Numbers

Recent ecological studies on culicine mosquitoes in and around a village in south-western Nigeria[1] revealed that the numbers of *Aedes aegypti* fluctuated throughout the year in a manner which could not be correlated with the observed external environmental factors. During a preliminary survey it was established that this species was restricted to breeding within the village area in clay water-pots of the type used for collecting and storing water, but that it was absent from natural habitats in the surrounding rain forest. The fact that it showed a typically domestic breeding pattern facilitated a study of the population dynamics throughout the year, and the method used for obtaining an index of breeding intensity was as follows. A number of clay pots were placed in the village and sampled weekly, the pre-adults (larvæ and pupæ) being removed for counting while the pots were cleaned and refilled with fresh water. The number of pre-adults found weekly was taken as an index of the changes in density of the breeding population within the village.

To study this numerical fluctuation of *A. aegypti* the value N was used as a population index for the village, it being equal to $n/(e)(w)$, where n is the total number of pre-adults taken per month, e is the number of experimental pots sampled per month and w is the number of weekly samplings per month. During the first four months of the year, N increased from 24·3 to 135·0, this being followed by a sharp decline in May (52·6), a slight increase in June (71·2) and a continued decline until October (21·3). There was then a further build-up, reaching a peak in December (71·2). It will be seen (Fig. 1) that these fluctuations were not related to the observed environmental factors, either directly or with a suitable time-lag to allow for the climate to be influencing the egg-laying behaviour of the female. It was thought that these fluctuations may have been dependent on density, related to the numbers of larvæ and pupæ found in the pots. Each pot may be considered as an isolated environment containing a unispecific population subject to intra-specific competition, such that any increase in numbers beyond a certain point would result in an increased pre-adult mortality due primarily to starvation.

An examination of this postulate was carried out in the laboratory in the following manner. A series of cultures was maintained, each containing different numbers of larvæ but in otherwise standard conditions of food supply and water volume. To ensure constant food supply, a solution of larval food was made up having the following constituents: wholemeal flour (46 per cent), ground oats (40 per cent), fish meal (8 per cent), dried skimmed milk (3 per cent), cod-liver oil (1 per cent), dried yeast

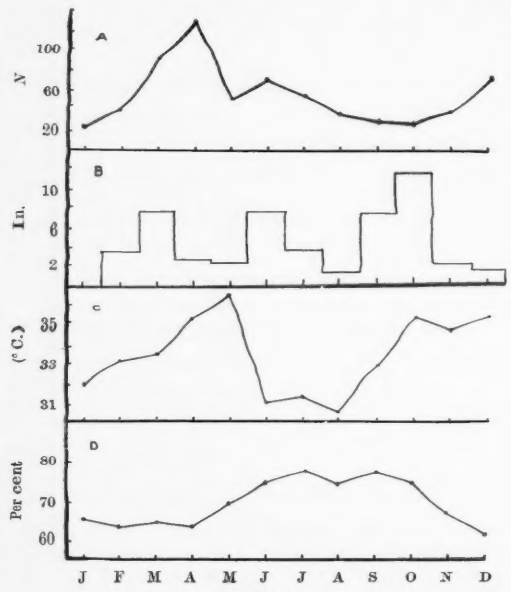

Fig. 1. *A*, the value of *N* for the village, 1956; *B*, the monthly rainfall; *C*, the monthly mean maximum temperature (° C.); *D*, the monthly mean minimum relative humidity (per cent). The monthly mean mimimum temperature varied in the range 18·1–20·5° and the monthly mean maximum relative humidity in the range 98·0–100 per cent

(1 per cent) and sodium chloride (1 per cent). 20 gm. of solid were added to 400 c.c. of water and heated to 100° C., the filtrate being used as the food solution. 40 c.c. of this were added to 1,000 c.c. of water and seven such cultures made up containing 10, 20, 30, 40, 50, 60, and 70 first instar larvæ respectively. A daily record was kept of development and mortality in each culture, the results for days 10 and 14 being given in Table 1.

In these laboratory experiments on the influence of population density on the survival and development of larvæ, each of the cultures described may be considered as a successive stage in the growth of a mosquito population.

In the field, the initial build-up may be accounted for by the early rains resulting in the hatching of the eggs which had remained viable over the dry season. At the time of the field study no rain fell between November 12, 1955, and February 9, 1956, but viability has been shown to persist in this strain for at least 24 weeks[2]. Thus the smallest culture may be taken to represent the commencement of the breeding season with the onset of the rains in February, each successive culture being a further stage in growth of population. It has been shown that in otherwise standard conditions, the greater the number of larvæ the longer the developmental period and higher the mortality. Thus it may be suggested at this stage that, in the field, as the population increased and relatively greater numbers of eggs were laid, the limits of the pre-adult environments were approached, resulting in increased larval mortalities and a reduced egg-laying population. This decline was then followed by a recovery, it being suggested that there was adequate food material available for the smaller number of pre-adults. It may be concluded, therefore, on the present available evidence, that these fluctuations are essentially dependent upon density of population.

Table 1. Showing the Stages of Development on Days 10 and 14 of Cultures of *Aedes aegypti* Larvæ in Standard Conditions

Culture	No. of larvæ	Day 10	Day 14	Mortality (per cent)
1	10	8 IV, 2 III	10 *A*	0·0
2	20	20 III	20 *A*	0·0
3	30	30 III	15 IV	50·0
4	40	35 II	10 III	10·00
5	50	42 II	14 III	100·0
6	60	40 II	22 II	100·0
7	70	45 II	20 II	100·0

Note.—Roman numerals represent larval instars; *A* represents adults. After day 14 there was no further development in cultures 4–7.

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[1] Surtees, G., *Proc. Roy. Ent. Soc.*, A, **34** (in the press).
[2] Surtees, G., *W. Afr. Med. J.*, **7**, 52 (1958).

Prolonged Survival of *Trichomonas vaginalis* at −79° C.

Successful cultures have recently been obtained from a stock strain of *T. vaginalis* which had been stored in a carbon dioxide cabinet for 26 months. The previous maximum survival reported was four months[1]. Since 1954, freezing in the presence of 5 per cent glycerol has been used for the maintenance of a strain of *T. vaginalis*. Stock cultures in the cabinet are replaced at approximately six-monthly intervals. Survival of cultures is shown on thawing by actively motile Protozoa and successful subcultures. The known maximum period of survival of such cultures has gradually been extended first to 8 months and then to 12 months.

Recently, four ampoules which had been frozen in September 1956 were examined. The first of these showed a few sluggishly motile Protozoa and was dispersed in 10 ml. of culture medium. There was no growth, probably because the sudden exposure to a glycerol-free medium disrupted the surviving cells. The suspensions from the next two ampoules, which also showed very few active Protozoa, were each pipetted carefully to the bottom of separate tubes of medium so that the glycerol might diffuse out of the organisms as gradually as possible. Both these cultures grew, reaching maximum counts after 4 days incubation and thereafter subcultures grew normally.

The last ampoule was used in an attempt to obtain an accurate count of the proportion of surviving Protozoa. This failed, partly because the few survivors were too fragile to withstand the necessary manipulations and partly because many of the dead Protozoa were reduced to debris.

In all four samples active organisms were few and frail, and it may be that two years is close to the extreme period of survival for *T. vaginalis* under the conditions of storage, etc., used.

The growth and general appearance of the Protozoa after subculture were indistinguishable from a culture which had been stored for shorter periods, and both closely resembled the original culture prior to freezing. Antigens prepared from one of the recovered cultures and the one which had been more frequently passed were used for sensitizing sheep erythrocytes[2]. An anti-*Trichomonas vaginalis* rabbit serum, prepared in 1953, agglutinated red cells, sensitized with either

of these antigens, to the same titre. The titre observed was somewhat less than that obtained with the same serum and culture five years previously, a *difference which might be due to the age of the serum*. No tests of pathogenicity were performed. As so few of the Protozoa survive, it may be that cultures derived from these form a selected group—this possibility cannot be ruled out.

The extreme period of survival recorded is not in itself important; but it does suggest that cultures may be kept for as long as a year with every confidence of survival.

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[1] McEntegart, M. G., *J. Hyg.*, **52**, 545 (1954).
[2] McEntegart, M. G., *J. Clin. Path.*, **5**, 275 (1952).

A Toad (*Xenopus lævis*) without Hæmoglobin

de Graaf[1] has recently described a specimen of *Xenopus lævis* Daudin completely lacking hæmoglobin. Another specimen showing a similar condition was found in a practical class in this Department on September 20. The individual was a male measuring 6·5 cm. from the tip of the snout to the vent. Unfortunately it had been partly dissected under tap water and then left for some hours before my attention was directed to the specimen. It was one of a batch of toads delivered from the Trout Hatcheries near Kingwilliamstown in the Eastern Cape Province and had been in the laboratory for only five days before dissection.

As with de Graaf's specimen, the blood vessels were colourless or white except for the chromatophores in their walls; the heart was pale cream; the lungs and liver grey and, particularly striking, the kidneys cream. In contrast to the specimen found by de Graaf, the spleen appeared to be enlarged and was a light brown and not a slightly yellowish-white. The most remarkable feature, however, was that the gall bladder was rich in green bile pigment. This seems to suggest that extensive destruction of hæmoglobin had been occurring very recently.

de Graaf has shown that normal *Xenopus* are able to withstand functional elimination of at least 80 per cent of their hæmoglobin by carbon monoxide treatment. Although survival without hæmoglobin is clearly possible, he is careful to point out that this does not prove that an animal without hæmoglobin can be as active as a normal one. Nevertheless, in his discussion de Graaf appears to be assuming that his animal without hæmoglobin had been in that condition all its life, with the implication that growth to maturity in natural conditions is possible in the absence of hæmoglobin. The evidence that hæmoglobin destruction had only just been completed in the present specimen suggests a different interpretation—namely, that the totally anæmic condition is a pathological state which may arise after the adult has become mature. If this is correct then the existence of such individuals does not permit any conclusions to be drawn as to the importance of hæmoglobin for survival in natural conditions.

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[1] de Graaf, A. R., *J. Exp. Biol.*, **34**, 173 (1957).

Inhibition of Influenza Virus Multiplication with a Glucose Antimetabolite (2-deoxy-D-glucose)

Optimal *in vitro* multiplication of influenza virus in the chorioallantoic membrane of the chick embryo *is dependent upon the presence of glucose in the* medium[1]. Evidence on the importance of endogenous glucose in *in vivo* synthesis of influenza virus is lacking. The relatively low toxicity in both experimental animals[2] and humans[3] of the potent glucose *antimetabolite 2-deoxy-D-glucose suggested the* feasibility of employing this compound in *in vivo* influenza virus infection. The present studies, undertaken in the intact chick embryo, demonstrate that the synthesis of influenza virus is markedly inhibited by 2-deoxy-D-glucose. *Ancillary studies* with *in vitro* systems show this inhibition to be reversible with glucose and therefore not related to permanent host cell damage.

The results of two representative experiments are shown in Fig. 1. In these experiments groups of six 10-day-old chick embryos were injected by the allantoic route with 12·5 or 25·0 mgm. of 2-deoxy-D-glucose or with water as a control. 18 hr. later, large inocula of influenza *B* (Lee) virus were introduced by the same route. These inocula were sufficiently large ($10^{7.5}$ *EID*50, Exp. 559; $10^{8.0}$ *EID*50, Exp. 560) to establish simultaneous infection of all susceptible cells to ensure a 'one-step' growth-curve. 8 and 24 hr. after the inoculation of virus, allantoic fluids from individual eggs were harvested and titrated with 0·5 per cent human '*O*' erythrocytes for the presence of viral hæmagglutinin. The geometric means of titres within groups were calculated and are plotted in Fig. 1. At 8 hr., viral concentrations in control eggs were close to maximal, while yields in eggs injected with 2-deoxy-D-glucose were

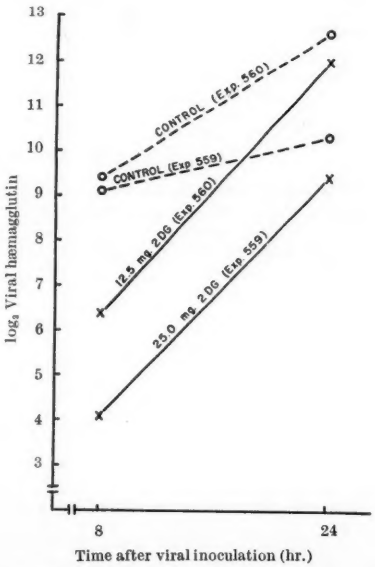

Fig. 1. Yields of influenza virus in allantoic fluids of chick embryos after prior injection of 2-deoxy-D-glucose (2DG). Geometric mean concentrations of virus derived from six individually titrated samples (allantoic fluids)/group. Chick embryos inoculated 18 hr. after injection of 2-deoxy-D-glucose with $10^{7.5}$–10^{8} 50 per cent egg infectious doses (*EID*50) of influenza *B* (Lee) virus

3·0–5·0 $\log_2$ (8–32-fold) less. At 24 hr., however, hæmagglutinin concentration in eggs injected with 2-deoxy-D-glucose did not differ significantly ($>1·8$ $\log_2$) from control values. The apparent diminution in the inhibitory effect of 2-deoxy-D-glucose suggested: a declining efficacy of the metabolic block with time, or a slowed rate of viral synthesis with a delayed attainment of maximal titre as synthesis proceeded via less-efficient metabolic pathways not blocked with 2-deoxy-D-glucose. That the first interpretation is incorrect was demonstrated by an experiment in which virus was introduced 42 hr. after 25·0 mgm. of 2-deoxy-D-glucose at a time equivalent to the termination point of the experiments previously cited. The depression of yield of virus at 8 hr. was identical with that seen before. Hence it appears unlikely that interference with glucolysis had abated. This interpretation is supported by the failure of large amounts (50–250 mgm.) of glucose to prevent or reverse the effect of 2-deoxy-D-glucose in the intact chick embryo, although the effect induced *in vivo* was reversible *in vitro* by washing of chorio-allantoic membranes and the addition of supplementary glucose prior to virus infection. It is of interest that pyruvate, which may substitute for glucose in the *in vitro* synthesis of influenza virus[4], proved capable of inhibiting to a degree the restrictive effects on virus multiplication induced by 2-deoxy-D-glucose in the chick embryo. The utilization of pyruvate presumably is not blocked with 2-deoxy-D-glucose.

Other experiments have shown that synthesis of infective as well as hæmagglutinating virus is depressed with 2-deoxy-D-glucose, and that the ratio of hæmagglutinating to infective virus formed is equivalent to that of controls.

Preliminary experiments in mice have failed to demonstrate effects of 2-deoxy-D-glucose on either virus multiplication or the development of viral lesions. Further study of this relatively non-selective type of chemotherapy seems indicated, however, in view of the low toxicity of this antimetabolite. The possibility emerges that mere retardation of virus growth with preservation of host cell integrity may permit suppression of infection until natural host defences can be mobilized.

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[1] Daniels, J. B., Eaton, M. D., and Perry, M. E., *J. Immunol.*, **69**, 321 (1952).
[2] Ball, H. A., Wick, A. N., and Sanders, C., *Cancer Res.*, **17**, 235 (1957).
[3] Landau, B. R., Lazlo, J., Stengle, J., and Burk, D., *J. Nat. Cancer Inst.*, **21**, 485 (1958).
[4] Levine, A. S., Bond, P. H., and Rouse, H. C., *Proc. Soc. Exp. Biol. and Med.*, **93**, 233 (1956).

Whale Remains in Glacier Ice

The preservation of Pleistocene or Recent land mammals in the Siberian permafrost has long been known, but the literature does not appear to include mention of marine mammals preserved in ice. Particular interest, therefore, is attached to the discovery in 1958 of part of a whale carcass entombed in the ice-cored moraine of Sveabreen, Ekmanfjord, in Vestspitsbergen. The north-eastern lateral moraine of Sveabreen projects into the fjord about two miles beyond the ice-front, and the find was made by members of the Birmingham and Exeter Universities Spitsbergen Expedition near the seaward tip.

The ice-core of the moraine rises to about 20 ft. above the high-water mark and the dirt cover is probably about 3 ft. thick. Near the top of the ice-core, and within the adjacent moraine, the bones and (now decomposing) flesh and skin of a whale were found. Melting of the ice and the removal of moraine seem to be uncovering more of the carcass each year and, from what could be seen, much of the body behind the shoulder region appears to remain. Several of the posterior vertebræ are exposed on the upper surface of the moraine so that their dorsal surfaces have suffered some damage. The head and shoulders have been carried away during present-day erosion of the moraine, which consists here largely of water-worn pebbles and small boulders and mud containing "raised beach" fossils typical of the "*Mytilus* horizon", that is, of the Sub-Recent period. Weathered-out vertebræ and ribs were found on the shore. The length of the existing part of the animal is about 30 ft. so that its length when complete must have been about 60 ft.

The question of how and when the animal became entombed is a difficult one. One would expect a dead whale to float and hence decompose during the summer months, even if it died in the winter. It is suggested, therefore, that this specimen was trapped beneath ice, possibly the floating ice-front of Sveabreen, and held there. Advance of the ice pushed the whale, together with sediment and the enclosed shelly fauna, from the fjord floor to the position where the moraine so formed is now situated. The long axis of the whale is more or less parallel to the length of the moraine. It may be fortuitous that it lies at the top. As long as it remained in the permafrost the animal would not decompose. It is surprising that the body remained intact during the movement.

A regional recession of the ice in the Arctic has been taking place during the past 200 years and certainly Sveabreen has retreated some two miles during the past 45 years. The whale must have reached its present position at least before this recession began and probably during the previous major advance of the ice, which occurred as a result of a severe deterioration of the climate in Sub-Recent times. Ahlmann[1] suggests that this advance may have occurred about 2,500 years ago. Since then, and with the further recession of the glaciers, isostatic recovery has raised the Sub-Recent littoral deposits on the Ekmanfjord coast 2–3 m. above sea-level and with them the overlying ice-cored moraine. Thus it may be surmised that the carcass of the whale reached its present site most probably more than 200 years ago but not more than 2,500 years ago. This time-interval is a large one; but radiocarbon dating would perhaps narrow the likely limits within which the whale died.

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University of Exeter.

P. A. Garrett

Geology Department,
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[1] Ahlmann, H. W., *Norsk geogr. tiddsk.*, **13** (1954).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, January 26

INSTITUTE OF ACTUARIES (in Staple Inn Hall, High Holborn, London, W.C.1), at 5 p.m.—Mr. Hilary L. Seal: "A Statistical Review of the Evidence for the Existence of Temporary Selection".

UNIVERSITY OF LONDON INSTITUTE OF EDUCATION (in the Assembly Hall, Malet Street, London, W.C.1), at 5.30 p.m.—Dr. C. A. Mace: "Field and Gestalt Theories".*

INSTITUTION OF ELECTRICAL ENGINEERS (at the Royal Festival Hall, London, S.E.1), at 6 p.m.—Dr. H. A. Thomas: "Automation" (Faraday Lecture).

RADAR AND ELECTRONICS ASSOCIATION (at the Royal Society of Arts, John Adam Street, London, W.C.2), at 7 p.m.—Mr. D. W. Fry: "The Pinch Approach to Thermonuclear Reactions".

Tuesday, January 27

UNIVERSITY COLLEGE (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. L. Brent: "A New King of Twin".*

ROYAL SOCIETY OF ARTS, COMMONWEALTH SECTION (at John Adam Street, Adelphi, London, W.C.2), at 5.15 p.m.—Sir Vivian Fuchs: "The Commonwealth Trans-Antarctic Expedition" (Thomas Holland Memorial Lecture).

UNIVERSITY OF LONDON (in the Anatomy Lecture Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. G. W. Beadle (California Institute of Technology): "Transmission Mechanisms"*. (First of two lectures on "Mendelian Inheritance". Further lecture on February 3.)

SOCIETY OF INSTRUMENT TECHNOLOGY (at Manson House, Portland Place, London, W.1), at 6 p.m.—Symposium on "Flow Measurement".

ROYAL AERONAUTICAL SOCIETY (at 4 Hamilton Place, London, W.1), at 7 p.m.—Mr. P. Lloyd: "Some Aspects of the Engine Noise Problem".

SOCIETY FOR VISITING SCIENTISTS (at 5 Old Burlington Street, London, W.1), at 7.30 p.m.—Discussion Meeting on "New Light on Vision". Chairman: Prof. W. D. Wright. Speakers: Prof. R. W. Ditchburn, Prof. C. H. Graham and Dr. W. A. Rushton, F.R.S.

Wednesday, January 28

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. R. J. Firman: "The Relationship between Joints, Faults and Mineral Veins in the Eskdale Granite (Cumberland) and the adjacent Borrowdale Volcanic Series"; Dr. W. I. Stanton: "The Lower Palæozoic Rocks of South West Murrisk, Ireland" (Paper read by Dr. G. Thomas).

INSTITUTION OF ELECTRICAL ENGINEERS, SUPPLY SECTION (in conjunction with the BRITISH NUCLEAR ENERGY CONFERENCE, at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. A. E. Harwood, Mr. P. Scott and Mr. B. H. Stonehouse: "Design of Electro-Mechanical Auxiliaries Directly Associated with Power-Producing Reactors".

UNIVERSITY COLLEGE (in the Eugenics Theatre, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. A. Hald (University of Copenhagen): "A Survey of some Sampling Inspection Plans for Attributes".* (Further lecture on January 30.)

CHALLENGER SOCIETY (at the Linnean Society, Burlington House, Piccadilly, London, W.1), at 5.45 p.m.—201st Scientific Meeting. Dr. Marston C. Sargent: "Growth and Photosynthesis in the Giant Kelp of the Pacific Coast".

INSTITUTE OF INFORMATION SCIENTISTS (at the Berners Hotel, 10 Berners Street, London, W.1), at 6 p.m.—Discussions on (1) Abstracting, (2) Information Retrieval with respect to the results of the International Conference on Scientific Information, held at Washington, November 1958.

INSTITUTION OF MECHANICAL ENGINEERS, EDUCATION GROUP (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Discussion on "Teaching of the Theory of Structures and Strength of Materials".

BRITISH INSTITUTION OF RADIO ENGINEERS, LONDON SECTION (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Prof. D. B. Fry: "Theoretical Aspects of Mechanical Speech Recognition"; Mr. P. Denes: "The Design and Operation of the Mechanical Speech Recognizer at University College London".

INSTITUTE OF SCIENCE TECHNOLOGY (in the Chemistry Lecture Theatre, University College, Gower Street, London, W.C.1), at 6.30 p.m.—Prof. Dame Kathleen Lonsdale, F.R.S.: "Peaceful Uses of Atomic Energy in the Next 50 Years".*

SOCIETY FOR ANALYTICAL CHEMISTRY, MICROCHEMISTRY GROUP (in the Restaurant Room of "The Feathers", Tudor Street, London, E.C.4), at 6.30 p.m.—Discussion on "The Determination of Small Quantities of Toxic Substances in the Atmosphere", opened by Dr. J. G. Gage.

PHARMACEUTICAL SOCIETY OF GREAT BRITAIN (at 17 Bloomsbury Square, London, W.C.1), at 7.30 p.m.—Mr. K. R. Fell: "A Pharmacognosist in Nepal".

BRITISH PSYCHOLOGICAL SOCIETY, MEDICAL SECTION (at the Royal Society of Medicine, 1 Wimpole Street, London, W.1), at 8.15 p.m.—Annual Meeting. 8.45 p.m.—Mr. A. Plaut: "Aspects of Consciousness" (Chairman's Address).

Thursday, January 29

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. A. Myers and Prof. R. D. Preston: "Fine Structure in the Red Algae", "The Structure of the Cell Wall of *Rhodymenia palmata*", "A General Survey of Cell Wall Structure in the Red Algae"; Mr. E. G. Gray: "Electron Microscopy of Collagen-like Connective Tissue Fibrils of an Insect".

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. C. T. Ingold, Mr. F. C. Webber and Dr. Irene M. Wilson: "Marine Fungi".

UNIVERSITY COLLEGE, FACULTY OF LAWS (in the Eugenics Theatre, Gower Street, London, W.C.1), at 5 p.m.—Mr. D. W. M. Waters: "The Rating of Charitable and Similar Institutions".*

INSTITUTE OF BIOLOGY, LONDON BRANCH (at 41 Queen's Gate, London, S.W.7), at 7.30 p.m.—Dr. R. L. Knight, O.B.E.: "Fruit-breeding—a Survey of Recent Work"* (Annual Research Survey No. 4).

Thursday, January 29—Friday, January 30

CHALLENGER SOCIETY (joint meeting with Representatives from the MARINE LABORATORIES (DEVELOPMENT COMMISSIONERS' SCHEME), in the Lecture Theatre of the British Museum (Natural History), London, S.W.7), at 10 a.m. daily—Scientific Papers.

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO AND TELECOMMUNICATION SECTION (at Savoy Place, London, W.C.2)—Convention on "Long-Distance Transmission by Wave-guide".

Friday, January 30

UNIVERSITY COLLEGE, DEPARTMENT OF PHARMACOLOGY (in the Physiology Theatre, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. W. V. Macfarlane (University of Queensland): "Chemical Agents and the Slow Potentials of Heart and Muscle Cells".*

UNIVERSITY OF LONDON (in the Eugenics Lecture Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. A. Hald (University of Copenhagen): "An Economical Sampling Inspection Plan based on *a priori* Distributions".*

INSTITUTION OF MECHANICAL ENGINEERS (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Dr. R. S. Silver: "The Energy Balance in Steam Power Plant Feed Systems".

WOMEN'S ENGINEERING SOCIETY, LONDON BRANCH (at Hope House, 45 Great Peter Street, Westminster, London, S.W.1), at 7 p.m.—Mrs. I. H. Hardwich: "Some Uses of Electron Beams in Metallurgy".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Mr. Yehudi Menuhin: "Art and Science as Related Concepts".

Saturday, January 31

LONDON COUNTY COUNCIL (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Mr. Frank Greenaway: "Chemistry in Antiquity".*

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER or LECTURER IN THE DEPARTMENT OF PURE MATHEMATICS—The Registrar, The University, Liverpool (January 31).

DIRECTOR (man or woman, of high ability, with considerable experience in chemical research and interest in its application in industry, able to lead and inspire a large research staff and organize and manage the work of the laboratory) OF THE NATIONAL CHEMICAL LABORATORY, D.S.I.R., Teddington, Middlesex—The Civil Service Commission, 17 North Audley Street, London, W.1, quoting S.4923/59 (February 2).

LECTURER (registered medical practitioner) IN MEDICINE—The Registrar, The University, Manchester 13 (February 2).

LECTURER IN MATHEMATICS; a LECTURER IN CHEMISTRY; and a LECTURER IN EDUCATION—The Secretary, Homerton College, Cambridge (February 6).

CYTOLOGIST (honours graduate in botany or agricultural botany), to undertake general cytological work, but will have an opportunity to engage in original research—The Secretary, Scottish Plant Breeding Station, Pentlandfield, Roslin, Midlothian (February 7).

LECTURER (specially qualified in one or more scientific subjects) IN THE INSTITUTE OF EDUCATION—The Registrar, The University, Liverpool (February 7).

LECTURER (Grade III or II) (with a good honours degree and some relevant research or teaching experience, preferably in the field of structures) IN THE DEPARTMENT OF CIVIL ENGINEERING—The Registrar, The University, Bristol 8 (February 16).

SENIOR LECTURER IN THE HISTORY AND PHILOSOPHY OF SCIENCE at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, February 16).

LECTURER (with special qualifications, and preferably some research experience in either glasshouse crops or fruit growing) IN HORTICULTURE—The Registrar (Room 22, O.R.B.), The University, Reading (February 18).

DIRECTOR (with proven scientific ability in the field of nuclear sciences such as radiochemistry, nuclear physics, isotope techniques or theoretical physics and an interest and proven ability in using such fields of work to solve a wide range of scientific and applied problems) OF THE INSTITUTE OF NUCLEAR SCIENCES, D.S.I.R., Wellington, New Zealand, to lead a research team of about forty scientists and carry out administrative duties therewith—The High Commissioner for New Zealand, 415 Strand, London, W.C.2, quoting Ref. No. *B*11/21/11 and mentioning *Nature* (February 20).

LECTURER or ASSISTANT LECTURER (with a degree in physiology, biochemistry, pharmacology or experimental zoology and research experience in one of these branches) IN THE DEPARTMENT OF PHYSIOLOGY AND BIOCHEMISTRY—The Secretary and Registrar, The University, Southampton (February 21).

READER IN BACTERIOLOGY at the Middlesex Hospital Medical School—The Academic Registrar, University of London, Senate House, London, W.C.1 (February 23).

DEMONSTRATOR or SENIOR DEMONSTRATOR IN GEOGRAPHY, primarily to supervise class work in physical geography—The Registrar, University of Melbourne, Carlton, N.3, Victoria, Australia (February 27).

LECTURER IN AGRICULTURAL CHEMISTRY (BIOCHEMISTRY) at the Waite Agricultural Research Institute, University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, February 28).

LECTURER IN ORGANIC CHEMISTRY, and an ASSISTANT LECTURER IN ORGANIC CHEMISTRY—The Secretary, The Queen's University, Belfast (February 28).

LECTURER IN PHYSIOLOGY—Prof. A. A. Harper, Department of Physiology, Medical School, King's College, Newcastle-upon-Tyne 1 (February 28).

LECTURER (with a degree in science or veterinary science and undertaken postgraduate studies in parasitology) IN HELMINTHOLOGY OR VETERINARY PARASITOLOGY at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1, or the Registrar, University of Queensland, Brisbane, Australia (February 28).

SENIOR LECTURER or LECTURER (preferably with a degree or diploma in veterinary medicine and a specialized knowledge of comparative physiology) IN THE DEPARTMENT OF VETERINARY PHYSIOLOGY; and a LECTURER (veterinary surgeon, or with a degree in physiology) IN PHARMACOLOGY—The Secretary, Royal Veterinary College (University of London), Royal College Street, London, N.W.1 (February 28).

SENIOR LECTURER, and either a LECTURER or ASSISTANT LECTURER IN ZOOLOGY at Makerere College (The University College of East Africa)—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (March 1).

RESEARCH ASSISTANT IN MATHEMATICAL STATISTICS in the Department of Applied Mathematics—The Registrar, The University, Liverpool (March 2).

IMPERIAL CHEMICAL INDUSTRIES RESEARCH FELLOWS (2) IN CHEMISTRY, PHYSICS, ENGINEERING (including CHEMICAL ENGINEERING), METALLURGY, PHARMACOLOGY or related subjects—The Registrar, The University, Sheffield 10 (March 7).

IMPERIAL CHEMICAL INDUSTRIES RESEARCH FELLOWS IN BIOCHEMISTRY, CHEMISTRY and PHYSICS—The Registrar, University College, Dublin (March 31).

IMPERIAL CHEMICAL INDUSTRIES RESEARCH FELLOWS IN BIOCHEMISTRY, CHEMISTRY, CHEMOTHERAPY, ENGINEERING, METALLURGY, PHARMACOLOGY or PHYSICS—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 30).

TURNER AND NEWALL RESEARCH FELLOW IN ENGINEERING, INORGANIC CHEMISTRY or PHYSICS—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 30).

ASSISTANT EDITOR (full-time, with a university degree, preferably in the physical sciences, and interested in the general advancement of science—academic, industrial and social, no previous editorial experience necessary) of *Nature*—The Editor of *Nature*, Macmillan and Co., Ltd., St. Martin's Street, London, W.C.2.

HEAD (preferably aged 30–40, with a good degree and previous experience) OF THE CHEMISTRY DEPARTMENT—The Headmaster, Winchester College, Winchester.

LECTURER or SENIOR LECTURER (graduate in physics, teaching experience and preferably research and/or industrial experience) IN PHYSICS—The Principal, Kingston Technical College, Fassett Road, Kingston-upon-Thames.

NATIONAL RESEARCH COUNCIL and other POST-DOCTORAL FELLOWS IN THE DEPARTMENT OF PHYSICS—Prof. H. E. Duckworth, Chairman, Department of Physics, McMaster University, Hamilton, Ontario, Canada.

PHYSICAL CHEMIST (with an honours degree in chemistry and preferably a few years experience of applied research) IN THE BITUMINOUS SECTION of the National Institute for Road Research, South African Council for Scientific and Industrial Research, Pretoria, for work involving investigation of the different problems associated with the materials used for bituminous binders, and adhesion of tar, and bitumens to roadstone and the oxidation of tars and bitumens—The South African Scientific Liaison Officer, Africa House, Kingsway, London, W.C.2.

SCIENTIST (first- or second-class honours graduate in physics or electrical engineering), to be directly responsible to the Superintendent of Orfordness outstation for the general direction and day-to-day management of a team engaged on a programme of advanced electronic instrumentation development and associated complex field trials—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting Ref. No. 2131/34.

SENIOR TECHNICIAN IN THE RADIOTHERAPY DEPARTMENT—The Medical Superintendent, Western Infirmary, Glasgow, W.1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Forestry in England. Pp. 16. (London: Forestry Commission, 1958.) [1211

Report of the Commonwealth Trade and Economic Conference. Pp. 17. (Cmnd. 539.) (London: H.M. Stationery Office, 1958.) 1*s.* net. [1211

The British Council. Annual Report 1957–1958. Pp. vi+111+8 plates. (London: The British Council, 1958.) [1311

Is Management a Profession? By Lyndall F. Urwick. Second impression. Pp. 32. (London: Urwick, Orr and Partners, Ltd., 1958.) 3*s.* [1311

Tube Investments Limited. Chairman's Statement—Annual General Meeting, Grand Hotel, Birmingham, 8th December 1958. Pp. 12. (London: Tube Investments Limited, 1958.) [1311

The Presentation of Taxonomic Information: a Short Guide for Contributors to Flora Europaea. Compiled by V. H. Heywood. Pp. 24. (Leicester: The University Press, 1958.) 2*s.* 6*d.* net. [1311

Office of the Lord President of the Council. The Sheep Industry in Britain 1958: a Report by the Natural Resources (Technical) Committee. Pp. iv+52. (London: H.M. Stationery Office, 1958.) 3*s.* 6*d.* net. [1311

The National Gallery, July 1956—June 1958. Pp. 121+12 plates. (London: The National Gallery, 1958.) 10*s.* [1311

Government of Northern Ireland: Ministry of Agriculture. Leaflet No. 57: Have Eggs of First Quality. Pp. 8+4 plates. (Belfast: Ministry of Agriculture, 1958.) [1711

Bulletins of Marine Ecology (formerly Hull Bulletins of Marine Ecology). Edited by Sir Alister Hardy, Dr. C. E. Lucas and R. S. Glover. No. 40, Vol. 5: Continuous Plankton Records: List of Records, 1955–1957. By Dora E. John and W. W. Brown. Pp. 44–50+ plates 9–14. (Edinburgh: The Scottish Marine Biological Association, 1958.) 4*s.* 6*d.* [1711

Other Countries

United States Department of the Interior: Geological Survey. Professional Paper 293: Quaternary and Engineering Geology in the Central Part of the Alaska Range. A: Quaternary Geology of the Nenana River Valley and Adjacent Parts of the Alaska Range. By Clyde Wahrhaftig. B: Engineering Geology Along Part of the Alaska Railroad. By Clyde Wahrhaftig and Robert F. Black. Pp. viii+118+8 plates. n.p. Professional Paper 294-I: Structural and Igneous Geology of the La Sal Mountains, Utah. By Charles B. Hunt. Pp. iv+305–364+plates 39–45. n.p. (Washington, D.C.: Government Printing Office, 1958.) [1211

Western Australia: Geological Survey. Bulletin No. 111: The Exploratory Diamond Drilling of the Koolyanobbing Iron Deposits for Pyrite, Approx. Lat. 30° 50′ S., Approx. Long. 119° 45′ E. By H. A. Ellis. Pp. 141+2 plates. (Perth: Government Printer, 1958.) [1211

Food and Agriculture Organization of the United Nations. FAO Commodity Policy Studies No. 11: National Food Reserve Policies in Underdeveloped Countries. Pp. vi+70. (Rome: Food and Agriculture Organization of the United Nations; London: H.M. Stationery Office, 1958.) 5*s.*; 1 dollar. [1211

Symposium on Cancer of the Liver Among African Negroes held by the International Union Against Cancer, Kampala, Uganda, August 1956. (Union Internationalis Contra Cancrum, Acta, Vol. 13, Nos. 4–5.) Pp. 507–874. Symposium in Leopoldville, September, 1956. (Union Internationalis Contra Cancrum, Acta, Vol. 13, No. 6.) Pp. 875–975. (Louvain: Union Internationale Contre le Cancer, 1957.) [1311

United States Department of the Interior: Geological Survey. Water-Supply Paper 1424: Ground-Water Factors Affecting Drainage in the First Division, Buffalo Rapids Irrigation Project, Prairie and Dawson Counties, Montana. By E. A. Moulder and F. A. Kohout. Pp. vi+198+11 plates. n.p. Water-Supply Paper 1436: Surface Water Supply of the United States, 1956. Part 3-B: Cumberland and Tennessee River Basins. Prepared under the direction of J. V. B. Wells. Pp. viii+262. 1 dollar. Water-Supply Paper 1437: Surface Water Supply of the United States, 1956. Part 4; St. Lawrence River Basin. Prepared under the direction of J. V. B. Wells. Pp. x+407. 1.50 dollars. Water-Supply Paper 1438: Surface Water Supply of the United States, 1956. Part 5: Hudson Bay and Upper Mississippi River Basins. Prepared under the direction of J. V. B. Wells. Pp. xii+575. 1.75 dollars. Water-Supply Paper 1446: Surface Water Supply of the United States, 1956. Part 12: Pacific Slope Basins in Washington and Upper Columbia River Basin. Prepared under the direction of J. V. B. Wells. Pp. ix+346. n.p. Water-Supply Paper 1447: Surface Water Supply of the United States, 1956. Part 13: Snake River Basin. Prepared under the direction of J. V. B. Wells. Pp. viii+261. n.p. Water-Supply Paper 1463: Records of Springs in the Snake River Valley, Jerome and Gooding Counties, Idaho, 1899–1947. By R. L. Nace, I. S. McQueen and Arthur Van't Hul. Pp. v+62+2 plates. n.p. (Washington, D.C.: Government Printing Office, 1958.) [1711

Centro Brasileiro de Pesquisas Fisicas. Notas de Fisica. Vol. 4, No. 8: Angular Correlation in the Decay of Pions and Muons. By C. M. G. Lattes. Pp. 11+19 figures. Vol. 4, No. 9: A Cosmic Ray Jet in the 10^{15} Electron Volt Energy Range. By P. Fowler, P. S. Freier, C. Lattes, E. P. Ney and P. H. Perkins. Pp. 3+3 figures. Vol. 4, No. 10: A Model of the Universal Fermi Interaction. By J. Leite Lopes. Pp. 6. Vol. 4, No. 11: Note on Leptonic Decay of Pion. By Prem Prakash. Vol. 4, No. 12: Nuclear Emulsion Processing and Loading with Metal Versene Complex. By H. G. de Carvalho and A. G. da Silva. Pp. 5+1 figure. (Rio de Janeiro: Centro Brasileiro de Pesquisas Fisicas, 1958.) [1811

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